TECHNICAL MANUAL

ECONOMIC STUDIES FOR MILITARY CONSTRUCTION DESIGN–APPLICATIONS

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CHAPTER 1

INTRODUCTION

1-1. Purpose.

This manual establishes criteria and standards for economic studies for projects in the military construction program (MCP) and provides detailed guidance for implementing these criteria. This manual serves as an aid to design professionals in fulfilling their responsibility to base decisions on sound economic studies, in accordance with current policy.

1-2. Scope.

This manual has been developed as a complete, self-contained document and includes all the information needed to perform the economic studies required for MCP projects. More specifically, this manual contains:

– A full, detailed and unified presentation of the criteria and standards that govern the conduct of the life cycle cost (LCC)—based economic studies required by Department of Defense (DOD) and higher authorities for MCP projects.
– Step-by-step instructions for performing life cycle cost analyses (LCCA) and related calculations in response to current requirements.
– Numerous worked-out examples of the individual calculations.
—Examples of complete life cycle cost analyses
– Tabular materials and sample worksheets developed to minimize the amount of calculation involved in economic studies and to maximize their effectiveness.

1-3. Background.

The design of a facility in the MCP may be viewed as a series of decisions or choices among alternative methods for satisfying functional requirements. The design progresses as each of these decisions is made and implemented—that is, as particular design alternatives are selected for use in the facility and incorporated into the design. In general, the basis for selecting particular alternatives for implementation is minimum life cycle cost.

a. Life cycle costs. The LCC for a facility (or for a design alternative) is the sum of all the costs that are expected to be incurred as the facility (or the design alternative) performs its function over a period of time. This sum is sometimes referred to as the *total cost of ownership*. It includes the costs of design, construction/procurement, energy, maintenance, operation (other than energy), repairs, alterations, and disposal.

b. Advantages of using LCCs. The LCC of a design alternative is the most complete indicator of the expected cost of obtaining, utilizing, and disposing of the alternative. Thus, LCCs provide the most valid basis for comparing the costs of completing design alternatives and for selecting the feasible alternative with the lowest cost. In addition, the LCC procedure permits careful consideration of the use, cost, and conservation of energy-an advantage particularly important in the design of MCP facilities, where the achievement of significant reductions in energy consumption is a statutory requirement.

c. Life cycle costs in economic studies. Life cycle cost analysis is a systematic procedure for measuring and comparing the LCC of two or more design alternatives and selecting the most cost effective one for implementation. The totality of all life cycle cost analyses performed for a particular MCP project, along with the related overall management effort, is referred to in this manual as the *economic study* for the project.

1-4. Cost data.

The objectives of this manual are satisfied in large part by means of illustrative material, which in most cases is presented in the form of simulated case histories for MCP projects. These simulated case histories were developed at the beginning of calendar year 1982, and utilize cost information that generally reflects market prices and cost-growth projections of that timeframe. (The differential escalation rates for fuel and energy, for example, are taken from projections developed by the Department of Energy for the Federal Energy Management Program (FEMP), Commercial Sector, and contained in the 1982 edition of the Code of Federal Regulations, in accordance with standard practice throughout the Department of Defense at that time.) In a number of cases, however, cost figures were constructed, or adjusted, primarily for instructional advantages (i.e., to help make a point). It is important for the reader to recognize that the simulated case histories presented herein were developed primarily for the purpose of illustrating the proper interpretation and the proper implementation of the criteria of chapter 2 and the calculational procedures described in the other chapters of this manual. *They were not intended to provide cost guidance for future life cycle cost studies; nor were they intended to provide design guidance for future life cycle cost studies on the relative economic rankings of competing design alternatives.* Current market prices must be obtained on a case-by-case basis at the time an economic study is conducted, and cost-growth projections must be obtained in accordance with the provisions of chapter 2.

1-5. References.

The following documents are referenced in this manual:

Code of Federal Regulations (CFR) Title 10 (Energy) Part 436, Subpart A (10 CFR 436A)

Office of Management & Budget (OMB) Circular No. A-94, "Discount Rates to be Used in Evaluating Time-Distributed Costs & Benefits".

Department of Defense Construction Criteria Manual DoD 4270.1-M.

Army Regulation AR 11-28, "Economic Analysis and Program Evaluation for Resource Management".

Environmental Protection Agency EPA Manual 430/9-78-009.

CHAPTER 2

CRITERIA AND STANDARDS

2-1. Introduction.

This chapter establishes criteria and standards for conducting LCC-based economic studies as an integral part of the design of facilities in the MCP. These criteria and standards apply to all Headquarters, Department of Army (HQDA) elements and all field operating activities (FOAs) having Army construction design responsibility. They stem from requirements of three types:

Type 1. A basic requirement established by the Department of Defense Construction Criteria Manual (DoD 4270.1-M) for general design applications.

Type 2. Special requirements established by statute or by executive order for specific design applications such as energy-saving designs and wastewater treatment facilities.

Type 3. Special requirements established within the appropriate DoD headquarters office for one-time or limited application. Economic studies undertaken in response to requirements of type 1 are to be conducted in accordance with the provisions of paragraph 2-2 below and are referred to herein as *general economic studies.* Economic studies undertaken in response to requirements of types 2 and 3 are to be conducted in accordance with the provisions of paragraphs 2-3 through 2-6 below and are referred to as *special directed economic studies.* The criteria and standards for both general and special directed economic studies are illustrated by example in chapters 3 to 6 and appendix A, and implementation guidelines are presented in those chapters. Any further clarification and any additional guidelines that may be required may be obtained by request, through normal channels, to HQDA (DAEN-ECE-G), WASH DC 20314-1000.

a. General economic studies

(1) *Requirements.* DOD 4270.1-M specifies that economic studies be conducted routinely as part bf the design process for all military facilities and that these studies consider the LCC of the facilities. Moreover, the provisions of DOD 4270.1-M cover the evaluation of design alternatives throughout the facilities acquisition process—from early planning stages through construction—and apply to both initial-design decisions and design-modification decisions. Consequently, LCC-based economic studies are required in support of pre-design studies, value engineering activities, and preparations for major construction modifications, as well as in support of concept and final design.

(2) *Objectives.* The overall objective of a general economic study is to determine the relative economic rankings of all design alternatives under consideration. For most design features, standard practice calls for the designer to select the alternative that is to be implemented; in such cases the principal specific objective of the study is to identify the one design alternative that promises to be most economical for the application at hand. For those design features where standard practice calls for the construction contractor to make the selection (from a list of approved alternatives provided by the designer), the principal specific objective of the study is to identify the least economical of the various design alternatives under consideration, so that they may be proposed for deletion from the list of options provided in the project documents, in accordance with normal procedures for deviations.

(3) *Basic criteria and standards.* Basic criteria and standards for the conduct of all economic studies by and for the Department of Army are contained in AR 11-28, Economic Analysis and Program Evaluation for Resource Management. This technical manual is consistent with AR 11-28 but is limited to the design of individual MCP facilities.

b. Special directed economic studies.

(1) *Requirements and sources.* The broad, general requirements for LCC studies may be supplemented from time to time by special economic-study requirements of more limited scope. Such special study requirements generally are either higher-authority requirements or HQDA or Office of the Secretary of Defense (intra-DOD) requirements.

—Higher-authority requirements are those established by higher authority than the Department of Defense–generally by statute or executive order and generally for government-wide or MCP-wide application. Requirements of this type are currently in effect with regard to energy-conservation efforts—general efforts required for all new Federal facilities and special efforts to make use of solar energy and other renewable energy sources that are required specifically for MCP facilities–and the design of all new wastewater treatment facilities. These requirements, which are intended for permanent application, are addressed in paragraphs 2-3 to 2-5.

—DOD requirements for special economic studies are usually intended for only one-time or limited application. Some are limited to a single MCP project or to several closely related projects in the MCP. Others are limited to the projects in a single program year. Such requirements are addressed in paragraph 2-6.

(2) *Objectives.* The objectives of special directed economic studies generally depend on the source.

– Studies directed by higher authority are usually required to help insure the attainment of a newly established national goal, such as energy conservation or the development of innovative wastewater treatment technology.

– One-time or limited intra-DOD directed studies may be required for various reasons: to collect supporting data requested by a congressional committee; to insure that a certain type of study is conducted for a particular project or project type; to encourage consideration of a wide variety of alternative designs for a design feature that has been found to be a maintenance and repair problem; to evaluate the effect of a proposed change in criteria on the design of a particular type of facility; and so on.

(3) *Criteria.* The criteria and standards governing the conduct of special directed economic studies are presented in paragraphs 2-3 to 2-6.

–Paragraphs 2-3 and 2-4 address the special economic studies required by statute for energy conservation—i.e., for the use of extraordinary energy-saving design initiatives to conserve energy in new Federal facilities. The focus in paragraph 2-3 is on those general efforts to conserve non-renewable forms of energy that are required of all new Federal facilities. The focus in paragraph 2-4 is on those special efforts to utilize solar energy and other renewable energy sources—in a passive as well as in active sense—that are required specifically of MCP facilities.

—Paragraph 2-5 addresses special economic studies for the application/implementation of innovative/alternative wastewater treatment technology.

—Paragraph 2-6 addresses special intra-DOD directed economic studies.

Each type of special study–whether of higher authority or DOD origin-is to be conducted as described in this manual with one exception: It will generally not be necessary to conduct a completely new, full-scale special economic study if the relative rankings of the various alternatives under consideration have already been established for similar design conditions, in accordance with the appropriate governing criteria. In this circumstance, only two items will generally be required: a simple analysis update that takes into account all significant differences (in data, assumptions, etc.) between the previous study and the present study and a written record of the pertinent facts and conclusions, supported by an appropriately annotated copy of the documentation for the previous study and prepared in accordance with the provisions of paragraph *2-2d* below.

2-2. General economic studies.

General economic studies are performed in response to the requirements of DOD 4270.1-M.

a. Management considerations: Study scope and coverage.

(1) *Scope of study effort.* The basic DOD requirement for LCC-based general economic studies (para 2-la(l)) applies to all projects in the MCP. However, the scope of the economic study effort for each project will be determined individually, to insure the cost effectiveness of the study effort itself.

(2) *Coverage.* In a few specific types of design situations, an LCCA is required regardless of the cost-effectiveness potential of the study effort. These situations are as follows:

–Situations covered by special directives and requirements, such as those addressed in paragraphs 2-3 to 2-6.

–Situations in which the decision among design alternatives is heavily influenced by factors other than long-term economy; such factors may include strong user preference for a particular alternative and recommendations derived from value engineering studies or other cost-reduction initiatives.

—Situations that involve the consideration of an innovative design-for example, a design that is not provided for by current criteria or one that is not normally selected for the application being considered.

In these particular situations, an LCCA will be conducted unless the relative economic rankings of the various alternatives under consideration have already been established for similar design conditions. In all other situations, LCCA coverage will be determined primarily on the basis of cost effectiveness. Experience has shown that an LCCA of a design feature or facilities category that meets one or more of the following conditions is most likely to be cost effective in any given situation:

–The feature or category is itself cost intensive (i.e., high in LCC) relative to the project being designed, in terms of either initial construction/procurement costs or continuing costs that are incurred after the beneficial occupancy date (BOD)–especially the latter. Post-BOD continuing costs include fuel/energy, maintenance, custodial, and repair costs.

–The leading design alternatives for the feature or category are characterized by cash flows that are fundamentally different from each other (for example, one alternative has high initial costs and low post-BOD continuing costs, a second alternative has low initial costs and high post-BOD costs, and a third alternative exhibits a cash-flow pattern intermediate between the two).

—The feature or category is common to a number of projects, so that the LCCA results could be applied to several other projects in the MCP.

Accordingly, except as noted below, the economic study for all projects in the MCP will cover—as a minimum-all design features and facilities categories that meet one or more of these conditions.

(3) *Exceptions.* An LCCA *is not required* for a particular design feature if such analysis would be responsive *only* to the general requirements of DOD 4270.1-M and, in addition:

–It can be shown that the cost of the LCCA is likely to exceed any saving that could be achieved, even if the results of the study proved to be clear-cut; or

–The relative economic rankings of the various alternatives under consideration have already been established for similar design conditions; or

–The projected cost of studying the design feature, when added to the cost of LCCAs already conducted or planned for other design features of the same project, would cause that total cost to exceed one percent of the programmed amount for the project.

b. Life cycle cost analysis. The basic underlying principles and the most commonly used techniques of LCCA for facilities design are described in detail in a variety of readily available publications on the subjects of engineering economics and LCCA. The basic criteria and standards that govern the application of these principles and techniques in response to the requirements of DOD 4270.1-M are presented in the subparagraphs that follow. Subparagraphs (1) through (6) establish the general parameters for the LCCA: the alternatives to be included in the analysis for any given design feature, in subparagraph (l); the basic analysis approach, in (2); the timeframe for the analysis, in (3); the time value of money to be used, in (4); the unit of measurement or monetary standard, in (5); and the form in which the results of the analysis are to be expressed, in (6). Subparagraph (7) deals with costs and other monetary considerations, including the treatment of inflation and cost growth, and subparagraph (8) deals with the project calendar and other timing considerations. The treatment of uncertainties is presented in subparagraph (9). Subparagraph (10) provides an overview of the key provisions of this paragraph.

(1) *Design alternatives.* All design alternatives that are determined to be feasible for the application at hand—and only those alternatives–will be considered in each LCCA. A design alternative is feasible for a particular application if it satisfies at least the minimum established requirements for the project and for the MCP as a whole; these include functional requirements, technical criteria, energy-conservation criteria, standards for environmental quality, land use, health, safety, security, and, where applicable, budget constraints.

(2) *Analysis approach.* Current and future cash flows will be combined, compared, and analyzed utilizing the present-worth (PW) discounting approach. The “present time” to which all costs will be discounted is the date on which the analysis period begins-the analysis base date (see para 2-2 b(3)(a) below).

(3) *Analysis period.* The analysis period is the period of time over which the LCC for each design alternative is to be determined. The date on which it begins is referred to herein as the analysis base date (ABD) or simply the base date. The date on which it ends is referred to herein as the analysis end date (AED).

(a) Analysis base date. The ABD will be taken to be the date of study (DOS), the date on

which the study is actually performed, in accordance with conventional practice.

(b) Analysis end date. The AED will be taken as the calendar date on which the projected economic life of the facility as a whole ends. However, because DOD envisions the economic life of most types of facilities and major facilities components to end on the order of 25 years after BOD for general planning purposes, projected values of the AED in excess of 25 years beyond the BOD must be justified in writing and for most types of studies must be approved by HQDA prior to use. Prior approval will not, however, be required for those types of studies for which the use of actual projected economic lives is specifically authorized by HQDA. When the economic life of any particular facility is projected to end less than 25 years beyond the BOD, the analysis period used for the LCC will be the period of time between the DOS and the date corresponding to the actual projected value of the economic life.

(4) *Time value of money.* The time value of money that will be used in all LCCAs is 10 percent per year. This rate, commonly referred to as the discount rate, is to be used with either standard interest formulas or tables to convert current cash flows and future cash flows to a common base for analysis. The prescribed annual discount rate of 10 percent should be viewed as the minimum "real" rate of return—i.e., the net rate of return, *over and above the rate of inflation—to* be achieved by public sector investments. The Office of Management and Budget, at the recommendation of the Joint Economic Committee of the Congress, has determined that withdrawal of investment capital from the private sector by taxation can be justified only when the capital is used to finance public-sector investments for which the real rate of return is at least equal to that achievable on the average in the private sector (estimated to be 10 percent).

(5) *Monetary standard.* All costs–both those initially established in accordance with the provisions of paragraph (7)(b) below and those escalated to the times they are actually incurred in accordance with the provisions of paragraph (7)(c) below–will be expressed in terms of constant dollars that reflect the purchasing power of the dollar on the ABD. Accordingly, the proper unit of measurement for all costs and other monetary considerations, the monetary standard for the LCCA, is constant ABD dollars.

(6) *Analysis results.* The results of the LCCA will be expressed as a set of net present worths—one for each feasible alternative. The net PW (or net LCC) for an alternative is the difference between the sum of the PWs of all costs that would be incurred and the sum of the PWs of all monetary benefits that would be derived, if that alternative were implemented. Accordingly, the results of the LCCA will consist of a' set of net PWs on the ABD, each expressed in constant ABD dollars.

(7) *Costs and other monetary considerations.* The LCCA must take into account, for each design alternative, all the costs that would be incurred and all the monetary benefits that would be accrued throughout the analysis period as a result of selecting that particular design alternative. Even costs (or benefits) that may not be directly associated with some particular design alternative must be included in the net cost estimate for that alternative, so long as the costs (or benefits) are attributable to that alternative. For example, when an LCCA is conducted to determine the most economical type of exterior wall for a certain building, the costs associated with heating and cooling the building over the analysis period, and in many cases the original cost of the heating-ventilating air conditioning (HVAC) system, must be included in the net LCC estimate for each wall type. Both the procurement cost and the operating cost of the HVAC system are attributable, at least in part, to the type of wall selected.

(a) Types. As a general rule, *relevance* and *significance* are the determining factors for including particular costs or monetary benefits in the analysis: A cost or benefit will be included if it is relevant to the facility under design and the design feature under analysis and its projected magnitude is significant in comparison to other relevant costs that are included in the LCCA. All costs that are expected to be incurred throughout the analysis period will at least be considered for inclusion in the LCCA. Initial procurement costs, energy and operating costs, and maintenance, custodial, repair, and replacement costs will be relevant and significant to almost all analyses. The relevance and significance of other types of costs (such as design and redesign costs, terminal costs, downtime costs, and functional-use costs) and of monetary benefits (such as salvage and other forms of income, cost reductions, and marketable by-products) will have to be established on a case-by-case basis. Sunk costs (costs incurred prior to the analysis base date) are not relevant to LCCA results and will, therefore, not be included in the analysis.

(b) Data sources. Construction and other initial procurement costs will be determined in

accordance with existing MCP cost engineering criteria, guidance, and design practice, with two exceptions: There will be no allowances for contingencies or for supervision and administration (S&A) costs, and all costs will be expressed in terms of "ABD dollars" (and not in terms of program year or construction year dollars). Operating costs associated with fuel/energy consumption will be based on the results of an energy analysis. Other types of operating costs, maintenance-type costs (i.e., maintenance, custodial care, repair, and replacement costs), and other costs of ownership, as well as the times at which such costs are likely to be incurred, will be determined on the basis of the best available information at the time the LCCA is conducted. In many cases, the type of information required will be difficult to obtain from an independent and reliable source, in a form that is useful to the designer. As a result, the best available information obtained from any single independent source often will be no better than a "best guess." Consequently, the data used in the typical LCCA will have to be "constructed" from information gleaned from a variety of sources. Possible sources include the Directorate of Facilities Engineering (DFE)/Directorate of Engineering and Housing (DEH) staff, other facilities engineers, technical consultants, colleagues and other design professionals with previous experience in the area, manufacturer/industry representatives and literature, handbooks, trade-journal articles, Government publications, and technical articles, etc. The sources most appropriate for any particular application will have to be determined on a case-by-case basis. Regardless of the data/information sources actually used, all costs will be initially estimated as if they were to be incurred on the ABD, so that they are expressed in terms of ABD dollars, in accordance with the provisions above. Maintenance-type cost data that are constructed (rather than measured from historical data) will be consistent with all applicable Engineered Performance Standards and based on assumed standards of performance, cleanliness, aesthetics, etc., that are the same for all alternatives under consideration.

(c) Inflation and cost growth. The rate of inflation of the economy as a whole will be neglected in all LCC calculations. (The inflation rate is irrelevant to the LCCA results, because all cash flows are expressed in constant ABD dollars and discounted according to a "real" rate of return which reflects the time value of money over and above inflation.) Accordingly, in projecting future costs, an allowance for cost growth will be made only for particular costs that are expetted to change at rates greater than or less than the general rate of inflation. In such a case, the rates of cost growth used in the analysis will be *differential* rates of growth-that is, the anticipated difference between the growth rate of each particular cost and the general inflation rate. In general, in the absence of reliable information to the contrary, the differential rate of cost growth will be assumed to be zero. In the case of fuels and electricity, however, the differential rate of cost growth should be that prescribed by HQDA for general economic study applications.

(8) Project calendar and other timing considerations.

(a) Project calendar. The timing of all project events, i.e., the beginning, end, and midpoint of construction, the BOD, the dates on which cash flows occur, etc., will be based on the actual calendar dates on which the events are projected or scheduled to occur.

(b) Continuing costs. The present worth approach to LCCA is a cash-flow approach, in that in theory all costs are to be charged at the time at which they are actually incurred. In practice, the standard procedure is to accumulate continuing costs of the same type over some convenient period of time, and to charge all such costs incurred during that period as a single lump sum cost. Accordingly, all initial procurement costs will be accumulated and charged as a single lump sum cost, preferably at the time corresponding to the midpoint of the construction/procurement process. Similarly, all continuing costs of the same type incurred after the construction/procurement process is completed will be accumulated on an annual basis, beginning at the BOD, and charged as a series of single annual lump sum costs, preferably at the middle of the year (i.e., the first cost in the series charged six months after the BOD).

(9) *Uncertainties.* The input data for an LCCA are based on estimates rather than known quantities and are, therefore, uncertain. They may be uncertain as to the scope or quantity of things (e.g., pounds of steel, manhours of labor), the unit costs of things in the marketplace at the time the costs will actually be incurred, and the timing of cost (e.g., when a floor covering will require replacement). The effects of uncertainties on the results of an LCCA can be quite significant. They may distort the results of the analysis or dominate them so that one alternative may appear to be lowest in net LCC under one set of reasonable assumptions and highest in net LCC under another equally reasonable set of assumptions. For

these reasons, the need for uncertainty assessment will be considered as part of every LCCA.

(a) Specific requirements. The decision as to whether or not an uncertainty assessment is required for any particular LCCA will depend on a number of factors and so must be made on a case-by-case basis. Among these factors are: whether or not the LCCA results appear to be clear-cut; whether or not the relative economic rankings of the (apparently) top-ranked alternative and its nearest competitors could be affected by the results of the assessment; whether or not the LCCA results have to be approved by higher Command authority prior to implementation; and whether or not the LCCA results are likely to be controversial (as are deviations from criteria, changes from common practice, rejections of special user preferences, and significantly greater initial cost requirements that result in only marginal LCC savings). In general, an uncertainty assessment need not be performed if either of the following conditions applies:

- The relative economic rankings of the (apparently) top-ranked alternative and its nearest competitors cannot be affected by the results of the assessment.
- The LCCA results appear to be clear-cut—either clearly conclusive or clearly inconclusive—in advance.

In addition, even if the LCCA results appear not to be clear-cut-i. e., not clearly conclusive and not clearly inconclusive (especially the latter)—an uncertainty assessment is not considered necessary, provided the design decision is a routine one (i.e., one which may be implemented locally, without the need for higher-authority approval), and is one that is unlikely to be controversial when implemented.

(b) Approaches. Of the two leading approaches to uncertainty assessment, the probabilistic approach is the more direct and the more generally applicable for MCP designs, and it should be used whenever appropriate. Since the rigorous probabilistic approach is too complex for routine use, reasonable approximations to that approach are preferred for MCP design applications. The other leading approach to uncertainty assessment, the sensitivity y approach, may be used in any situation in which the approach is valid; however, in all cases in which the probabilistic approach and the sensitivity approach are both valid, the probabilistic approach is to be preferred. In those situations where neither the probabilistic approach nor the sensitivity approach can be considered to be valid, uncertainty assessment may be accomplished by means of any common-sense heuristic approach—preferably one based on either the probabilistic or the sensitivity approach, or on some combination of the two.

(10) *Summary.* An overview of these provisions is provided in table 2-1, both for general summary purposes and for convenience in comparing these provisions with the corresponding provisions for special directed economic studies. The key provisions are as follows:

- Standard PW discounting (10 percent per OMB A-94; DOS base date).
- Costs measured in constant dollars (DOS dollars).
- Analysis period through economic life of facility (Limit: 25 years beyond BOD).
- Real future price level changes.
- No substantive artificialities (real project calendar; actual market prices).

Table 2-1. LCCA criteria overview: general economic studies for MCP designs

Category	*Provisions*
BASIC CONSIDERATIONS	
–Time value of money basis	Net terms
–Cost measurement basis	Constant dollars (base date)
METHODOLOGY FEATURES	
–Scope of costs & benefits	Dollar quantifiable, all attributable
–Cash flows	Conventional (mid-year accumulation of frequently recurring costs)
–Common time	Base date
–Uncertainties	Assessment required when critical to economic ranking order
–Special credits/penalties	None
–Results	Net LCC (PW)
DATA & PARAMETERS	
–Discount Rate	10% net
–Base Date	Date of study
–Analysis period	Base date through economic life or 25 years from BOD (whichever is less)
—Inflation & cost growth	
°US economy	NA

Table 2-1. LCCA criteria overview: general economic studies for MCP designs—Continued

Category	*Provisions*
°Energy (avg. annual A)	Per HQDA
°Non-energy (avg. annual A)	Actual projections; 0% if uncertain
–Cost figures basis	
"Energy	Actual prices (base date)
"Other	Actual prices (base date)
–Project calendar	Actual projected timing

c. Economic ranking of alternatives.

(1) *General principles.* The alternative with the lowest calculated net LCC will be ranked most economical; the alternative with the next lowest net LCC will be ranked second; and so on, down to the alternative with the highest net LCC, which will be ranked least economical. If any alternatives are determined to have comparable net LCCs—either because their calculated net LCCs are essentially equal or because the uncertainties associated with the analysis are found to be sufficiently large to render apparent net LCC differences inconclusive–then their relative rankings will be based on a combination of energy-conservation and initial procurement cost considerations, as outlined below. For those situations in which the LCCA results appear not to be clear cut, the criteria for judging whether apparent net LCC differences are conclusive or inconclusive—and, hence, whether the LCCA results are conclusive or inconclusive—are as follows;

—A positive net LCC difference between two alternatives is conclusive if it can be shown that the probability of that difference exceeding zero is no less than 0.60.

—A positive net LCC difference between two alternatives is inconclusive if it can be shown that the probability of that difference exceeding zero is no greater than 0.55.

Finally, in the absence of net LCC determinations—either because an LCCA has not been conducted or because one has been conducted, but not in strict accordance with the criteria contained herein (e.g., it was not based on the best information available at the time) —design alternatives will be given economic rankings based solely on initial procurement cost considerations.

(2) *Tie-breaking.* If two design alternatives have comparable net LCCs, and it can be demonstrated with a high degree of confidence that one of these alternatives satisfies any of the following conditions, then that alternative will be assigned the higher relative ranking:

—It will be less expensive in terms of initial procurement costs *and* will consume no more fuel/energy per year; or

–It will consume less fuel/energy per year *and* will be no more expensive in terms of initial procurement costs; or

—It will consume at least 15 percent less fuel/energy per year *and* will not be more than 15 percent more expensive in terms of initial procurement costs; or

—It will be at least 15 percent less expensive in terms of initial procurement costs *and* will consume no more than 15 percent more fuel/energy per year.

When the two alternatives are of different fuel/energy types, quantities of fuel or energy consumed annually will be determined in Btu equivalents, measured at the source, in accordance with standard practice within the Department of Defense for measuring energy savings. If none of these conditions is satisfied, then the two alternatives will be assigned the same ranking. In those cases when two or more of the alternatives considered for any design feature are tied for the highest ranking, selection will be based on the designer's judgement as to which of the alternatives tied for the top ranking represents the best overall choice—in terms of initial cost, energy consumption, and life cycle cost—for the application at hand.

d. Management considerations. Documentation and distribution

(1) *Basic requirement.* A written record will be provided for every economic study, regardless of the size of the project and the conclusiveness of the results. The written record will be made a part of the design documentation and included in the project file.

(2) *Content.* The specific areas covered in the documentation will depend to a large extent on the nature of the study—for example, the type and scope of the project and the design feature(s) analyzed. For this reason, the coverage will have to be determined on a case-by-case basis. Every written record will, however, include and highlight the major technical and administrative lessons learned. The documentation should describe in essence what was done and how it was done, what information and data were used and their source, and the principal findings or results. The written record should be complete enough to

stand alone as a project document; it should be comprehensible to an audience that is not familiar with either the study itself or the MCP project for which the study was performed.

(3) *Distribution.* There is no general requirement regarding the distribution of the written records of economic studies. Rather, the desirability of distributing such material should be determined at the conclusion of each study. Distribution among the appropriate design professionals within the organization-for the purpose of exchanging information and data—is considered to be good professional practice and is encouraged in all cases. Written records are likely to be of interest or use relative to other MCP projects if they document significant or unusual findings, design decisions that represent changes from common practice, deficiencies in current criteria, significantly improved procedures, and so on. Such records should be brought to the attention of appropriate elements of higher authority within the Command, including HQDA where appropriate, for possible dissemination to other FOAs and/or other appropriate Command action.

2-3. Special energy-conservation studies—non-renewable resources.

Special economic studies required by statute for energy conservation—i.e., for the use of extraordinary energy-saving design initiatives to conserve energy in new Federal facilities— are addressed in part below and in part in paragraph 2-4. As indicated in paragraph 2–1 *b* (3) above, the focus in this paragraph is on those general efforts to conserve non-renewable forms of energy that are required of all new Federal facilities.

a. Management consideration. Study scope and coverage.

(1) *Requirement.* It is a statutory requirement that the selection of an energy-saving design (or design feature) for any new Federal facility be supported by the results of a special LCC-based economic study—one conducted in accordance with standard procedures and criteria specifically developed for this purpose under the FEMP. The criteria and standards presented throughout this paragraph are based on, and are completely compatible with, the criteria and standards which have been developed for the FEMP and (in accordance with the provisions of statute) included in the Code of Federal Regulations (CFR)–Title 10 (Energy), Part 436, Subpart A (10 CFR 436A). (The designations FEMP and 10 CFR 436A are used interchangeably herein.) It is important for the analyst to realize, however, that the nature of the FEMP material is such that it requires periodic modifications and updating. This is particularly true for DOE projects of fuel-and-energy price-level changes (see paragraph 2-3b(7) below) and the analysis base date upon which these projections are based (see paragraph 2-3b(3) below) –criteria which DOE may be expected to update as frequently as once a year (perhaps more frequently). It is the specific FEMP criteria in effect at the time each study is initiated (or contracted for) that governs the conduct of that study. Up-to-date information ‘on the DOE fuel-and-energy price-level projections and on all other aspects of the FEMP criteria that are current and in effect at any given time is available by request, through normal channels, to HQDA (DAEN-ECE-G), WASH, DC 20314-1000.

(2) *Application.* The statutory requirement–which is applicable to all energy-consuming elements of a facility, whether energized (eg., chillers) or non-energized (e.g., exterior walls) -is considered to be limited to extraordinary energy-saving design initiatives. That is, it is considered to be applicable only to those special design situations where one or more of the design alternatives under consideration are being considered primarily for the extraordinary energy-saving potential that they offer in comparison with the more “conventional” energy-saving design alternatives that are already provided for by current general-purpose DOD/DA design criteria. In other words, the statutory requirement is applicable to special design situations devoted to energy conservation, where one (or more) of the design alternatives under consideration in an LCCA represents an extraordinary energy-saving design initiative (i.e., one not provided for by current criteria, or provided for, but only by special criteria developed specifically for purposes of energy conservation). On the other hand, the special statutory requirement does not apply to routine design-tradeoff decisions, in which the only types of alternatives considered in the LCCA are those provided for by current general-purpose criteria. (In such cases, the criteria of paragraph 2-2 above govern.)

b. Life cycle cost analysis. The criteria and standards prescribed in the FEMP for LCCAs conducted in support of extraordinary energy-saving design initiatives are presented in the subparagraphs that follow. Subparagraphs (1) through (6) establish the general parameters for the LCCA: the alternatives to be included in the analysis for any given design feature, in subparagraph (1); the basic analysis approach, in (2); the time frame for the analysis, in (3); the time value of money to be used, in (4); the unit of measurement or monetary standard, in (5); and the form in which the results of the analysis are to be expressed in (6). Subparagraph (7) deals with costs and other monetary considerations, including the treatment of inflation and cost growth, and subparagraph (8) deals with the project calendar and other timing considerations. The treatment of uncertainties is presented in subparagraph (9). Subparagraph (10) provides an overview of the key provisions of this paragraph. (It will be seen that these criteria and standards are the same as those presented in paragraph 2-4b below—i.e., those for special energy-conservation studies that focus on the utilization of renewable energy resources.)

(1) *Design alternatives.* The design alternatives considered in an LCCA that is conducted in response to—or in conformance with— statutory requirements for energy conservation must include at least one extraordinary energy-saving design determined to be feasible for the application at hand and at least one feasible ' 'conventional" design. In the typical situation, one to three energy-saving designs are considered, along with one "conventional" design-generally the "best" one, the one found to be most economical (i.e., highest ranked), in accordance with the provisions of paragraph 2-2 above. (Accordingly, the "conventional" design alternative is often referred to, and treated as, the "baseline alternative," against which the various energy-saving alternatives are compared.) The criteria normally used to establish the feasibility of an alternative for a particular design application can be found in paragraph 2-2b(l) above. These criteria apply in energy-conservation LCCAs as well, except that—in the case of an extraordinary energy-saving design initiative–feasibility generally may not be denied either on the basis of budget constraints (i.e., the CWE will exceed the programed amount, if the design in question is implemented) or on the basis of criteria limitations (i.e., the design is not provided for by current DOD/DA criteria), or both. Such a design, so long as it is judged to be feasible in all other respects, may generally be rejected only on economic grounds, in accordance with the provisions of statute. It should be noted that the types of energy-saving designs included in the LCCA need not be limited to the types addressed in this paragraph-i. e., those utilizing non-renewable forms of energy (primarily). Should the designer find it convenient and desirable to do so in any particular case, one or more alternatives of the types addressed in paragraph 2-4 could be included as well.

(2) *Analysis approach.* Current and future cash flows will be combined, compared, and analyzed using the present-worth (PW) discounting approach. The present time to which all costs will be discounted is the date on which the analysis period begins-the analysis base date (see para 2-3 b(3)(a) below).

(3) *Analysis period.* The analysis period is the period of time over which the LCC for each design alternative is to be determined. The date on which it begins is referred to herein as the analysis base date (ABD) or simply the base date. The date on which it ends is referred to herein as the analysis end date (AED).

(a) Analysis base date. The date to be used as the base date for the analysis is specified by the FEMP criteria and is included in 10 CFR 436A. This date is, however, subject to periodic updating, and it is the specific date prescribed for the FEMP at the time the study is initiated (or contracted for) that is to be used in each case as indicated in paragraph 2-3a(1) above. (The date specified by the FEMP criteria as the base date for the analysis-i. e., the first day of the base year-corresponds to the effective date of the fuel/energy prices cited in the criteria, and so in updated each time the FE MP-based fuel/energy prices are updated.)

(b) Analysis end date. The analysis period extends from the base date over a period of time that constitutes the projected economic life of the facility as a whole or 25 years, whichever is less. Accordingly, the AED will follow the base date by an amount of time equal to the economic life of the facility or 25 years, whichever is less.

(4) *Time value of money.* The time value of money will be taken as 7 percent per year. This rate, commonly referred to as the discount rate, is to be used with either standard interest formulas or tables to convert current and future cash flows to a common base for analysis. The prescribed annual discount rate of 7 percent should be viewed as the minimum "real" rate of return—i.e., the net rate of return, over and above the rate of inflation-to be achieved by public-sector investments for energy conservation.

(5) *Monetary standard.* The provisions of paragraph 2-2b(5) apply without exception.

(6) *Analysis results.* The provisions of paragraph 2-2b(6) apply without exception.

(7) *Costs and other monetary considerations.* The provisions of paragraph 2-2b (7) apply, with the following exceptions:

– *Data sources.* In accordance with the provision of statute, all fuel/energy costs eventually are to be expressed in terms of "marginal" costs, as defined by the FEMP criteria, rather than in terms of actual market prices. However, until such time as marginal costs can be defined, developed, and published in the Federal Register for implementation by all Federal agencies, the interim approach prescribed by 10 CFR 436A will be used. The interim approach consists of two parts: One part prescribes that the actual market prices be used when the average annual costs of fuel/energy are estimated initially, and that the market prices will be those in effect on the base date. The other part prescribes that a 10 percent credit will be applied to all energy-conservation investments, to compensate for the fact that marginal fuel prices are not being used. (The proper way to apply the prescribed investment credit is to consider the initial investment cost of *each* alternative, for purposes of the analysis, to be 90 percent of the dollar cost amount actually estimated. This approach gives the desired effect.)

– *Data sources.* The nature of the FEMP-prescribed base date is such that the date on which the study is conducted will nearly always occur at some time later than the base date. In those situations where the time between the ABD (i.e., the most current prescribed ABD) and the DOS is substantial, *and* where—because of this–the designer/analyst would experience considerable difficulty in obtaining market prices in effect on the ABD, as required, the designer/analyst may use DOS market prices instead of ABD market prices in determining cost estimates initially (i.e., prior to escalation and discounting). Two conditions will be satisfied whenever this approximation is used, however: (1) DOS market prices will be used as the basis for *all* cost determinations in the particular LCCA, and (2) the DOS-based costs will be treated in the analysis as if they were in fact ABD-based costs—i.e., as if they in fact reflected the purchasing power of the dollar on the base date.

—*Inflation and cost growth.* In the case of fuels and electricity, the differential rate of cost growth will be the rate prescribed for the FEMP for the DOE Region in which the project is located at the time the study is initiated (or contracted for) as indicated in paragraph 2-3a(1) above. (The DOE Regions are shown in appendix C.) For all items other than fuels and electricity, the differential rate of cost growth will be assumed to be zero.

(8) Project calendar and other timing considerations.

(a) Project calendar. The timing of all project events will be measured relative to the analysis base date (i.e., the ABD as determined in accordance with the provisions of paragraph 2-3 b(3)(a) above). The beneficial occupancy date (BOD) will be presumed to be the ABD for purposes of the analysis. All events that are projected to occur between the DOS and the actual BOD—e.g., design and construction—will be presumed for purposes of the analysis to have occured on the ABD. The dates of occurrence of all events that are projected to occur after the actual BOD—e.g., cash flows associated with fuel/energy and maintenance-and-repair (M&R) actions–will be presumed for purposes of the analysis to be those dates on which they would have ocurred had the BOD in fact occurred on the prescribed base date. (For example, a cash flow that is projected to occur 5 years after the actual BOD will be presumed for purposes of the analysis to occur 5 years after the prescribed base date.)

(b) Continuing costs. The provisions of paragraph 2-2b(8)(b) apply, with one exception: The series of annual lump sum costs used to represent post-BOD continuing costs will be charged at the end of the year. (The single lump sum cost that represents all initial procurement costs is charged on the base date, since the midpoint of the construction/procurement process—according to the provisions of paragraph 2-3b)(8)(a) above—is to be presumed to have occurred on the base date.)

(9) *Uncertainties.* Assessment of the effects of uncertainty on the results of the analysis is not required. However, such an assessment is permitted by the provisions of the FEMP criteria for uncertainties associated with the cost data (but not those associated with cost timing), provided that the assessment is made by means of a sensitivity analysis.

(10) *Summary.* An overview of the provisions of paragraph 2–3b is provided in table 2-2, both for general summary purposes and for convenience in comparing these provisions with the

corresponding provisions for general economic studies. The key provisions of paragraph 2-3b are as follows:

– Standard PW discounting (7 percent; special standardized base date).
– Costs measured in constant dollars (base date dollars).
– Analysis period through economic life of facility (limit: 25 years beyond BOD).
– Real future price level changes (fuel/energy only).
– Several substantive artificialities (e.g.: standardized project calendar; 10 percent investment credit/marginal fuel costs;
— 3 percent discount "credit"; differential-escalation restriction for non-energy cost elements; and uncertainty-assessment restriation).

Table 2-2. LCCA criteria overview: special energy-conservation studies

Category	*Provisions*
BASIC CONSIDERATIONS	
–Time value of money basis	Net terms
–Cost measurement basis	Constant dollars (base date)
METHODOLOGY FEATURES	
–Scope of costs & benefits	Dollar quantifiable only
–Cash flows	Post-BOD: conventional (end-of-year accumulation of all costs) Pre-BOD: on base date
–Common Time	Base date
—Uncertainties	Assessment not required; sensitivity study permitted, but on cost data only
–Special credits/penalties	10% investment credit for energy-saving designs*
–Results	Net LCC (PW)
DATA & PARAMETERS	
–Discount rate	7% net
–Base date	Per HQDA
–Analysis period	Economic life, not to exceed 25 years
–Inflation & cost growth	
°US economy	NA
°Energy (avg. annual A)	Per HQDA
°Non-energy (avg. annual A)	0%
–Cost figures basis	
°Energy	Actual prices (base date)*
°Other	Actual prices (base date)
—Project time parameters	Artificial keyed to base date

* Interim provisions—see paragraph 2-3b(7)

c. Economic ranking of alternatives.

(1) *General principles.* The alternative with the lowest calculated net LCC will be ranked most economical; the alternative with the next lowest net LCC will be ranked second; and so on, down to the alternative with the highest net LCC, which will be ranked least economical. If any alternatives are determined to have equal or very nearly equal net LCCs, then those alternatives will be assigned the same ranking. It is a statutory requirement that the alternative determined to be most economical be incorporated into the facility in all cases.

(2) *Tie-breaking.* There is no FEMP-prescribed tie-breaking procedure for alternatives with equal or very nearly equal net LCCs. Accordingly, in those cases when two or more alternatives are tied for the highest ranking, selection will be based on the designer's judgment as to which of the alternatives tied for the top ranking represents the best overall choice—in terms of initial cost as well as energy consumption—for the application at hand.

d. Management consideration. Documentation and distribution. The provisions of paragraph 2-2d apply without exception.

2-4. Special energy-conservation studies—renewable resources.

Special economic studies required by statute for energy conservation—i.e., for the use of extraordinary energy-saving design initiatives to conserve energy in new Federal facilities-are addressed in part below and in part in paragraph 2-3. As indicated in paragraph 2-lb(3) above, the focus in this paragraph is on those special efforts to utilize solar energy and other renewable energy sources—in a passive as well as in active sense—that are required specifically of MCP facilities.

a. Management considerations. Study scope and coverage.

(1) *Requirement.* It is a statutory requirement that design initiatives based on the use of solar energy or other renewable forms of energy be considered for all MCP facilities where such designs have the potential to save fossil-fuel-derived energy. In each case, the decision to select or reject such an energy-saving design, whether active or passive (or hybrid) in nature, must be based on the results of a special LCC-based economic study–one conducted in accordance with standard procedures and criteria developed for this purpose under the Federal Energy Management Program (FEMP), except where specifically modified for MCP applications by the provisions of statute. The criteria and standards presented throughout this paragraph are based on, and are completely compatible with, the criteria and standards which have been developed for the FEMP, and (in accordance with the provisions of statute) included in 10 CFR 436A. (The designations FEMP and 10 CFR 436A are used interchangeably herein.) It is important for the analyst to realize that the nature of the FEMP material is such that it requires periodic modifications and updating and to understand the implications thereof (see paragraph 2-3a(1) above).

(2) *Application.* The statutory requirement applies to all projects in the MCP and-within those projects—to all design features that use significant amounts of fossil-fuel-derived energy.

b. Life cycle cost analysis. The criteria and standards prescribed in the FEMP for LCCAs conducted in support of extraordinary energy-saving design initiatives were presented in paragraph 2-3b above (and are not repeated here). In an LCCA conducted to be responsive solely to the special statutory requirement for energy conservation in MCP facilities (i.e., energy conservation by means of utilization of renewable resources), the design alternatives considered must include at least one feasible design concept that is essentially based on the utilization of a renewable energy resource, and at least one feasible design concept that does not utilize a renewable energy resource in any substantial way (i.e., it uses fossil-fuel-derived energy only). The typical LCCA considers one design of each type—(1) the "baseline alternative," generally the most economical design (for the application at hand) not utilizing a renewable energy resource, and (2) the proposed energy-saving design, based on the utilization of a renewable energy resource, which is evaluated economically in comparison with the "baseline." In any particular case, the "best" of the designs not making use of a renewable energy resource may turn out to be a "conventional" design, or it may turn out to be an extraordinary energy-saving design found to rank higher economically than any of the "conventional" design alternatives. It is important to note that, in the course of studying the possibilities for energy conservation in the design of an MCP facility, the designer need not necessarily treat the LCCA addressed in this paragraph and the LCCA addressed in paragraph 2-3b above as separate LCCAs. The two LCCAs may be combined into a single LCCA—without violating any of the provisions of statute—should the designer find it convenient and desirable to do so for the particular project at hand.

c. Economic ranking of alternatives. For all energy-conservation studies for which no special ranking requirements over and above those FEMP have been imposed, either by the Congress or by any higher level of authority within the executive branch, the economic ranking of the alternatives in the LCCA may be determined and reported either in absolute terms or in relative terms, whichever is considered to be more appropriate or preferable for the situation at hand. Generally, absolute rankings-those established on the basis of the life cycle costs (and benefits) of the individual alternatives themselves— are considered to be more appropriate and preferable for the design-type LCCA (i.e., the tradeoff analysis, where all the alternatives under consideration are in competition for a single application, and only one—the most economical one—will be selected). Similarly, relative rankings--those established relative to some "baseline alternative, " in terms of the cost-and-benefit advantages (or disadvantages) of each of the other alternatives in comparison with the baseline alternative-are generally considered to be more appropriate and preferable for the investment-type LCCA (i.e., the incremental analysis, where the proposed investment opportunities are evaluated in comparison with a given situation, in order to determine the economic feasibility of each, regardless of whether the various investment alternatives are mutually exclusive or not). These are not hard-and-fast rules, however, and either approach may be used for any given application. The net LCC is the traditional ranking measure for the absolute-ranking approach, and it will be used whenever the absolute-ranking approach is selected. Although there are several ranking measures in common use in conjunction with the relative-ranking approach—e.g., the LCC savings to be provided, the savings-to-investment ratio (SIR), and the discounted payback period (DPP)—the

LCC-savings measure will be used whenever this approach is selected. (One or more of the other ranking measures may be used in any particular design situation— and will be, in all cases where there is a specific special requirement to do so—but the use of those measures will always be in addition to, and not in place of, the LCC-savings measure.) The economic ranking criteria that will be used in conjunction with the absolute-ranking approach are those cited in paragraph 2-3c above; the criteria that will be used in conjunction with the relative-ranking approach are presented below. It will be seen that the provisions of the two sets of criteria are conceptually identical-i. e., differences exist only in terms of the prescribed format in which the data are to be calculated and presented—so that the rankings of the alternatives considered will always be the same, regardless of which approach is used. In other words, since all four of the ranking measures addressed above (the three types under the relative-ranking approach—LCC savings, SIR, and DPP—and the net LCC for the absolute-ranking approach) are interdependent in all cases, ranking by any one of them is tantamount to ranking by all four.

(1) *Ranking measures.* The basic ranking measure for the relative-ranking approach is the LCC-savings measure. The LCC savings–which refers to the savings in net LCC, expressed in PW terms, which will be achieved by the facility in question if the proposed energy-saving design is adopted—will be determined directly from the results of the LCCA, by algebraically subtracting the LCC (PW) of the proposed energy-saving design from the LCC (PW) of the baseline alternative (i.e., the most economical design not making use of a renewable energy resource). Other leading ranking measures for the relative-ranking approach are the SIR and the DPP, both of which require some additional calculations beyond those of the LCCA. The numerator of the SIR will be determined by algebraically subtracting the PWs of all operating-and maintenance-type costs (including fuel/energy costs) of the energy-saving design from those of the baseline design. The denominator of the SIR will be determined by algebraically subtracting the PWs of all capital costs (including initial investment costs, major replacement costs, net terminal costs—i.e., demolition and disposal costs less salvage value-and so on) that are attributable to the baseline design from those attributable to the energy-saving design. The DPP will be determined as that period of time (measured in years from the BOD) which, if selected as the analysis period for the LCCA, would result in an LCC (PW) savings of zero. The LCC-savings measure will be evaluated and documented whenever the relative-ranking approach is selected for use. The SIR and/or DPP measures will be evaluated and documented only in response to specific requirements for such information in certain special cases (e.g., the Congressional requirement for MCP facilities, established around 1980, that all three of the ranking measures addressed herein be evaluated and documented for all economic-feasibility LCCAs involving an active solar-energy system).

(2) *General principles.* The energy-saving design will be considered cost effective (in comparison with the baseline design) when the LCC (PW) savings is greater than zero and not cost effective when the LCC (PW) savings is less than zero. When the LCC (PW) savings is equal to zero, or very nearly equal to zero, the energy-saving design will be considered neither cost effective nor not cost effective. In terms of the other two ranking measures: the energy-saving design is cost effective when the SIR is greater than one or when the DPP—rounded up to the next whole number of years—is less than the analysis period of the LCCA (i.e., the criteria-based value of the analysis period, selected in accordance with the provisions of paragraph 2-3b(3) above); the energy-saving design is not cost effective when the SIR is less than one or when the DPP is greater than the criteria-based value of the analysis period; and, when the SIR is equal to one, or very nearly equal to one, or when the DPP is equal to, or very nearly equal to, the criteria-based value of the analysis period, the energy-saving design is neither cost effective nor not cost effective. Whenever the energy-saving design is determined to be cost effective, it must be incorporated into the design of the facility, or the facility may not be built, in accordance with the provisions of statute; conversely, when the energy-saving design is found to be not cost effective, it may not be incorporated into the design of the facility. (It should be clear *(a)* that the facility with the energy-saving design is *more economical* than the facility without the energy saving design (i.e., the baseline design) when the energy-saving design is determined to be cost effective, less *economical* when the energy-saving design is determined to be not cost effective, and *as economical* when the energy-saving design is determined to be neither cost effective nor not cost effective, and-accordingly-(b) that the general principles cited are identical in concept to those of paragraph 2-3c(1) above.)

(3) *Tie-breaking procedure.* There is no statutorily prescribed procedure for those cases in

which the energy-saving design is determined to be neither cost effective, nor not cost effective. Accordingly, in such cases, the decision concerning whether or not the energy-saving design should be incorporated into the design of the facility will be based on the designer's judgment as to the better overall choice for the particular application at hand, all things considered (i.e., life cycle costs, initial costs, energy consumption, etc.)

d. Management considerations. Documentation and distribution. The provisions paragraph 2-2d apply without exception.

2-5. Special studies for innovative/alternative wastewater treatment technology.

a. Management considerations. Study scope and coverage. It is a statutory requirement that all new Federal wastewater treatment facilities make use of innovative or alternative treatment processes and techniques (such as recycle and reuse techniques and land treatment) unless the LCC of the innovative/alternative treatment facility exceeds the LCC of the most cost effective conventional facility by more than 15 percent. The requirement is considered to apply to all new construction of such facilities, unless a waiver is granted according to the provisions of the statute.

b. Life cycle cost analysis. In accordance with the provisions of statute, at least one of the wastewater treatment concepts to be evaluated in the LCCA should qualify as an option that uses innovative or alternative treatment processes and techniques. Furthermore, no such innovative/alternative treatment facility may be rejected from consideration (i.e., considered not feasible for the application at hand) solely on the basis of budget constraints. Subject to these two restrictions, the provisions of paragraph 2-2b apply without exception.

c. Economic ranking of alternatives. All conventional treatment concepts included in the analysis will be ranked in accordance with the provisions of paragraph 2-2c. If two or more innovative/alternative treatment concepts are included in the analysis, these will be ranked solely on the basis of their LCCs: i.e., the innovative/alternative treatment concept with the lowest net LCC will be ranked the most economical, the concept with the next lowest net LCC will be ranked second, and so on. Finally, the net LCC of the top-ranked innovative/alternative treatment works will be compared with an amount equal to 115 percent of the net LCC of the top-ranked conventional option. If the net LCC of the innovative/alternative facility exceeds that amount, then the conventional wastewater treatment option will be ranked higher and selected. If, on the other hand, the net LCC of the innovative/alternative option is either equal to or less than that amount, then the innovative/alternative facility ranks higher and must be selected by law.

d. Management considerations. Documentation and distribution. The provisions of paragraph 2-2d apply without exception.

2-6. Special intra-DOD directed economic studies.

a. Management considerations. Study scope and coverage. Requirements for special economic studies are established from time to time by HQDA, or the Office of the Secretary of Defense; these studies have one-time or limited application in the MCP. Requirements that are limited to a single project or to several closely related projects in the MCP are transmitted by means of the design directive for the affected projects. Those that are limited to the projects in a single program year are transmitted through normal channels to all HQDA FOAs. Such requirements may be established for a number of reasons, as indicated in paragraph 2-1b(2). All special economic studies required by HQDA will be conducted as directed as to both scope and coverage.

b. Life cycle cost analysis, economic ranking, and distribution. The provisions of paragraphs 2-2b through 2-2d apply to special intra-DOD directed studies.

CHAPTER 3

PRESENT WORTH CALCULATIONS: CONVENTIONAL APPROACH

3-1. Introduction.

Current provisions of criteria, as set forth in' chapter 2, require that cash flows in economic studies for MCP projects be combined and compared via present worth discounting. The conventional approach to the calculation of PWs is illustrated in this chapter. This approach is universal in the sense that it provides step-by-step procedures for computing the PW of any cost that may be encountered. Costs are here meant to include expenditures incurred and monetary benefits received (such as income, savings, and net salvage value). In accordance with the provisions of chapter 2, the unit of measurement for all costs is constant dollars as of the analysis base date. Only costs that are expected to occur on or after the date of the study are considered; costs incurred prior to the date of the study are sunk costs, which, in accordance with conventional practice, are not included in economic studies for MCP projects. In paragraph 3-2, the calculations of the conventional approach are outlined and used to find the PWs of several general types of costs. In paragraph 3-3, the approach is used to apply the criteria of chapter 2 to three typical MCP design alternatives. All simulated case histories presented in this chapter were developed in January 1982, and all utilize cost information that generally reflects market prices and cost-growth projections of that timeframe (see para 1-4).

3-2. Calculations.

In the conventional approach, each cost is escalated and discounted in separate steps as necessary to determine its present worth. With regard to frequency of occurrence, all costs are classified as either one-time costs or annually recurring costs. The general calculational approaches for the two types of costs are very similar in nature.

a. Classification of costs for calculations. The various costs that may be incurred over the lifetime of a construction project or design element may be considered to be of four types with respect to frequency of occurrence.

—*One-time* costs are costs that are incurred only once during the life of the project or element. Examples include initial investment costs, terminal costs (or net terminal values), and the costs of some alterations and replacements.

–*Continuous* costs are costs that will be incurred periodically throughout a given year. Examples include the costs of fuel/energy and operations (non-energy), some maintenance and repair costs, and custodial costs.

–*Cyclical* costs are costs that are expected to be incurred several times over the life of the project or element, but less often than once per year. Examples include some alteration, repair, and replacement costs and some maintenance costs.

–*Annually recurring* costs are costs that are expected to be incurred once each year during the life of the project or element.

For the purpose of calculating its present worth, a cyclical cost is treated as a series of one-time costs. For example, the cost of overhauling a certain piece of equipment every 3 years would be treated as a one-time cost occurring 3 years after BOD, another one-time cost occurring 6 years after BOD, and so on. Similarly, for a continuous cost, the amounts incurred over each 12-month period are summed, and the sum is treated as an *annually recurring* cost. For example, a semi-annual operating cost of $1,100 is treated as an annually recurring cost of $2,200. These two conventions reduce the number of cost frequency types from four to two, so that only a "two-track" procedure is required to determine the PWs of all costs involved in MCP projects. (It should be noted that a series of uniformly escalating annual costs may be treated as an annually recurring cost series, and that is how such series are treated in this manual.)

b. Calculations for one-time costs. The present worth (on the analysis base date) of a one-time cost (in base date dollars) is calculated as follows:

Step 1: Estimate the amount of one-time cost as of the base date, and the time at which it will occur.

Step 2: Escalate this cost to the time at which it is actually to be incurred, using the differential escalation rate e.

Step 3: Discount the escalated future one-time cost to an equivalent PW on the base date, using the discount rate d.

The examples that follow illustrate this procedure for several typical and special cases. Subparagraph (1) illustrates the typical case in which the escalation rate is zero. Subparagraphs (2) and (3) cover, respectively, cases in which the escalation rate is positive and negative. The case illustrated in subparagraph (4), in which a cost is incurred on the base date, is typical of the criteria of paragraphs 2-3 and 2-4. Finally, subparagraph (5) illustrates the case in which the escalation rate changes during the anaylsis period. The data and calculations for these examples are organized on a sample worksheet (fig 3-1) taken from the full worksheet. The full worksheet in DA Form 5605-4-R (Life Cycle Cost Analysis Savings—To–Investment Ratio (SIR) and Discounted Payback Calculation). DA Forms 5605-R through 5605-5-R will be used for calculations of LCCAs. These forms will be locally reproduced on 8-1/2” x 11” paper. Copies for local reproduction purposes are located in the back of this manual. All results are rounded to an appropriate number of significant figures. (Use of the full worksheet is illustrated in para 3-3 and in chap 6.)

(1) Example: e = O. A $3,000 cost (estimated as of the base date) will actually be incurred 15 years from the base date. The cost is not expected to escalate at a rate greater than the general inflation rate, so the differential escalation rate e is zero. The discount rate is 10 percent. The PW of this cost is calculated as follows (the steps are illustrated in fig- 3-1):

Step 1: Enter a brief description of the cost, the number of years from the base date to cost incurrence, and the estimate of the cost on the base date. Check the appropriate box to indicate the dollar magnitude, or leave the boxes blank to denote “no multiplier.”

Step *2:* Calculate the escalation factor as (1 + e)”, where e is the escalation rate expressed as a decimal, and n is the number of years from the base date to the time of the expenditure; or, obtain it from table B-3. Here, the escalation factor is $(1 + 0.00)^{15}$ or 1.0. Enter this factor, and then multiply it by the cost on the base date to establish the escalated cost at year 15 as 1.0 x 3.0 = 3.0.

Step *3:* Calculate the discount factor as 1/(1 + d)” or [1/(1 + d)]”, where d is the discount rate expressed as a decimal; or, obtain it from table B-4. There, the discount factor is $1/(1 + 0.10)^{15}$ or 0.2394. Enter this factor, and then multiply it be the escalated cost to obtain the present worth (as of the base “ date) of 0.2394 x 3.0 = 0.72 or $720.

Given the long discounting period (15 years) and the O percent escalation rate, this result–a PW that is about one-quarter of the original base date cost—seems reasonable.

(2) Example: positive escalation rate. The data for a certain cost are: base date cost = $3,000; cost incurred 15 years after base date; e = +3 percent; d = 10 percent. The following steps are illustrated in figure 3-1:

Step 1: Enter input data (as in previous example).

Step 2: $(1 + e)^n = (1 + 0.03)^{15} = 1.558$ (or obtain from table B-3) 1.558 x 3.0 = 4.67

Step 3: $1/(1 + d)^n = 1/(1.1)^{15} = 0.2394$ (or obtain from table B-4) 0.2394 X 4.67 = 1.12 = $1,120

(3) Example: negative escalation rate. The data for a certain cost are: base date cost = $3,000; cost incurred 15 years after base date; e = – 3 percent, d = 10 percent. The following steps are illustrated in figure 3-1:

Step 1: Enter input data (as in previous examples).

Step 2: $(1 + e)^n = (1 - 0.03)^{15} = (0.97)^{15}$ = 0.633 (or obtain from table B-3)
0.633 X 3.0 = 1.90

Step 3: $1(1 + d)^n = 1/(1.1)^{15} = 0.2394$ (or obtain from table B-4) 0.2394 x 1.90 = 0.45 = $450

A negative escalation rate increases the effect of discounting so that this result is much smaller than the result of subparagraph (2) above.

(4) Example: cost incurred on base date is $75,000; e = 5 percent, d = 7 percent. The following steps are illustrated in figure 3-1:

Step 1: Enter input data (as in previous examples).

Step 2: $(1 + e)^n = (1 + 0.05)^0 = 1.00$
1.00 x 75.0 = 75.0

Step 3: 1/(1 + d)” = 1/(1.07)0 = 1.00
1.00 x 75.0 = 75.0 = $75,000

The reason for the equality of the cost as estimated at the base date and its PW as of the base should be obvious. Since no time elapses between cost estimation and cost incurrence (n = O), the cost can neither escalate nor be dis-

Step 1 | Step 2

One-Time Costs ☒ $ x 10³ ☐ $ x 10⁶	Years From ABD	Cost on ABD	Escalation Factor	Escal.Cost (Time Incurred)	Discount Factor	Present Worth on ABD
Example #1						
e = 0	15	3.0	$(1.0)^{15} = 1.0$	3.0	$\left(\frac{1}{1.10}\right)^{15} = 0.2394$	0.72
Example #2						
e = +0.03	15	3.0	$(1.03)^{15} = 1.558$	4.67	0.2394	1.12
Example #3						
e = −0.03	15	3.0	$(0.97)^{15} = 0.633$	1.90	0.2394	0.45
Example #4						
Cost incurred on	0	75.0	$(1.05)^0 = 1.0$	75.0	$\left(\frac{1}{1.07}\right)^0 = 1.0$	75.0
base date						
Example #5						
e = 0.04 (yrs. 1-6)	10	2.0	$(1.04)^6(1.01)^4$	2.63	$\left(\frac{1}{1.07}\right)^{10} = 0.5083$	1.34
e = 0.01 (yrs. 7-10)						

Figure 3-1. One-time cost calculations

counted. This situation occurs in analyses performed according to the criteria of paragraph 2-3 and 2-4, when initial procurement costs are changed on the ABD (which is also presumed to be the BOD).

(5) Example: variable escalation rate. A cost estimated as $2,000 as of the base date will be incurred in 10 years. For the first 6 years, this cost is expected to escalate at 4 percent per year; for the remaining 4 years, the cost is expected to increase at 1 percent per year (both escalation rates are in excess of the general inflation rate). The discount rate is 7 percent. The PW of this cost is calculated as follows (the calculation is illustrated in fig 3-l):

Step 1: Enter input data (as in previous examples).

Step 2: Calculate the overall escalation factor as the product of two simple escalation factors $(1 + e_1)^{n_1}$ x $(1 + e_2)^{n_2}$, where the cost will escalate at rate e_1 for n_1 years and at rate e_2 for n_2 years. Here, the overall escalation factor is $(1 + 0.04)^6 \times (1 + 0.01)^4 = 1.317$. Enter this factor, and multiply it by the cost at the base date to obtain 1.317 x 2.0 = 2.63 as the escalated cost.

Step 3: Enter the discount factor 0.5083 (from table B-4) and multiply it by the escalated cost to obtain 0.5083 x 2.63 = 1.34 or $1,340 as the PW as of the base date.

c. *Calculations for annually recurring costs.* The most general form of a series of uniformly escalating costs is shown in the cash flow diagram in figure 3-2. The present worth (on the base date) of such a series of costs is calculated as follows:

Step 1: Estimate the amount A_0 of the annually recurring cost as of the base date, and determine the number of costs k in the series.

Step 2: Escalate A_0 to the time at which the first cost in the series is to be incurred, using the escalation rate e. Call this the escalated cost, A_i.

Step 3: Determine, for the date on which A_i is incurred, the single cost that is equivalent to a series of k uniformly escalation annual costs, where the amount of the first cost is A_i and the escalation rate is 3. This single equivalent cost may be found with table B-1 or B-2 (for d = 7 or 10 percent, respectively) or calculated with the formula given below.

Step 4: Discount the single equivalent cost from the time the first annual cost is to be incurred to an equivalent PW on the base date, using the discount rate d.

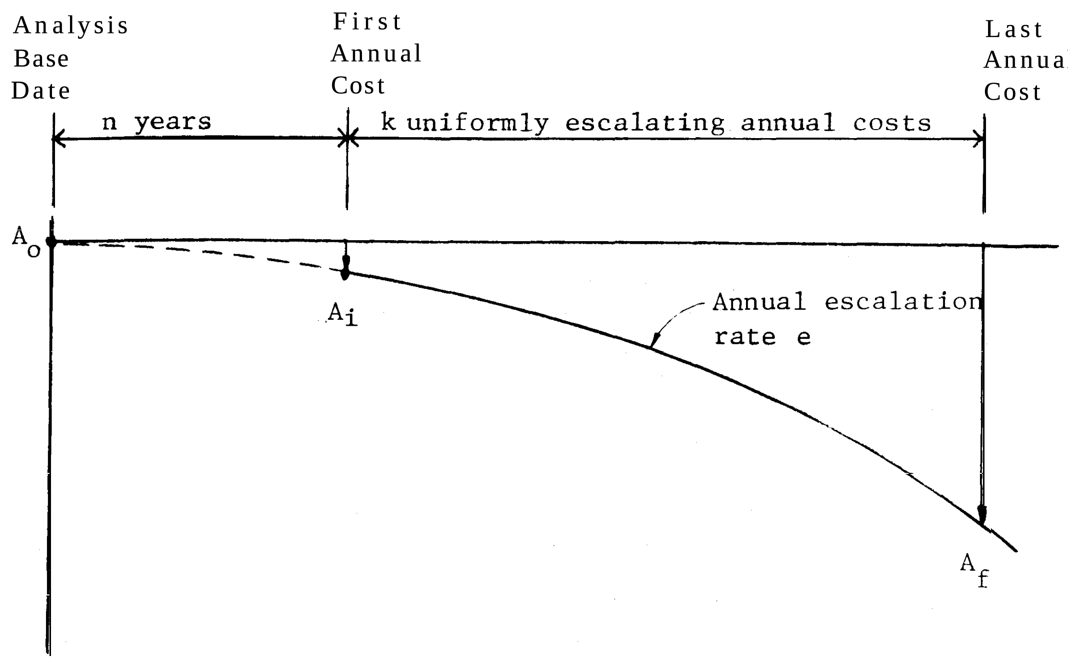


Figure 3-2. Series of uniformly escalating annual costs

A single (one-time) cost that is equivalent to a series of uniformly escalating annual costs may be found with the formula

$$P = \begin{cases} A_i(v^k - 1)/(v - 1) & \text{when } e \neq d \\ A_i k & \text{when } e = d \end{cases}$$

where P = equivalent one-time cost (at the time A_i is incurred)
A_i = amount of the first cost in the series
k = number of costs in the series
v = (1 + e)/(1 + d)
e = escalation rate, in decimals
d = discount rate, in decimals

As an example of the use of these formulas, consider a uniformly escalating annual cost that will be incurred for 25 years. The discount rate is 10 percent, and the escalation rate is 7 percent. The amount of the first cost in the series, at the time of the first annual payment, is A_i = $4,500. To determine the equivalent one-time cost *at that same time*, the value of v is first calculated as:

v = (1 + e)/(1 + d) = (1.07)/(1.10) = 0.9727

Then:

$(v^k - 1)/(v - 1) = (0.9727^{25} - 1)/(0.9727 - 1) = (-0.4994)/(-0.0273) = 18.293$

(This quantity is called the annual-series/one-time-cost equivalence factor, or, simply, the annual series equivalence factor.) Finally:

P = A_i x 18.293 = $4,500 x 18.293 = $82,300

Thus, the series of annually recurring costs is equivalent to (and may be replaced by) a one-time cost of $82,300 incurred at the time of the first annual payment. If the escalation rate and the discount rate were equal, the one-time equivalent cost would be computed as:

$P = A_1 k = \$4{,}500 \times 25 = \$112{,}500$

The examples that follow illustrate the procedure for calculating the present worth of a series of escalating annual costs. Those in subparagraphs (l) and (2) deal with escalation rates of zero those in subparagraphs (3) and (4) with positive and negative uniform escalation rates; and those in subparagraphs (5) and (6) with variable (nonuniform) escalation rates. The examples in subparagraphs (l), (3), (4), and (5) are typical of the criteria of paragraphs 2-2, 2-5, and 2-6. The examples in subparagraphs (2) and (6) are typical of the criteria of paragraphs 2-3 and 2-4. The data and calculations for these examples are organized on a sample worksheet (fig 3-3) taken from the full worksheet. (The full worksheet is DA Form 5605-4-R.) All results are rounded to an appropriate number of significant figures. (Use of the full worksheet is illustrated in para 3-3 and in chap 6.)

(1) Example: e = 0, n = 3.5. Annually recurring cost is estimated as $5,000 (as of the base date). The first annual cost will be incurred 3.5 years after the base date, and the series consists of 25 annual costs. The costs are not expected to escalate at a rate greater than the general inflation rate (e = O). The discount rate is 10 percent. The PW of this series of costs is calculated as follows (the steps are illustrated in fig 3-3):

Step 1: Enter a brief description of the cost, the number of payments (annual costs) in the series, the years in which the first and last payments will be incurred, and the annual cost at the base date (A_0). Check the appropriate box to indicate the dollar magnitude or leave the boxes blank to indicate "no multiplier." (Note that the last cost is incurred in n + k - 1 years from the ABD.)

Step 2: Calculate the escalation factor for the first annual cost as $(1 + e)^n$, where e is the escalation rate expressed as a decimal, and n is the number of years from the base date to the time of the first payment; or, obtain it from table B-3. Here, the escalation factor is $(1 + 0.0)^{3.5} = 1.00$. Enter this factor, and then multiply it by the cost on the base date to establish the escalated cost of 1.0 x 5.0 = 5.0 for the first payment A_1 at year 3.5.

Step 3: Calculate the annual series equivalence factor as $(v^k - 1)/(v - 1)$, or obtain it from table B-2. Here, its value is 9.985. Enter this value, and multiply it by the escalated first annual cost to obtain the escalated equivalent one-time cost of 9.985 x 5.0 = 49.9.

Step 4: Calculate the discount factor as $1/(1 + d)^n$, where d is the discount rate expressed as a decimal, and n is the time from the base date to the first annual cost; or obtain it from table B-4 (after interpolation). Here, the discount factor is $1/(1 + 0.10)^{3.5} = 0.7164$. Enter this factor, and multiply it by the equivalent one-time cost to obtain 0.7164 x 49.9 = 35.7 or $35,700 as the present worth at the base date of the annually recurring cost of $5,000.

(2) Example: e = 0, n = 1. The data for a certain cost are: base date cost = $5,000; k = 25 annual payments; d = 7 percent; e = 0; first payment due 1 year after base date. The following steps are illustrated in figure 3-3:

Step 1: Enter input data (as in previous example).

Step 2: $(1 + e)^n = (1 + 0.0)^1 = 1.0$ (or obtain from table B-3) 1.0 X 5.0 = 5.0

Step 3: $(1 + e)/(1 + d) = (1 + 0.0)/(1 + 0.07) = 0.9346$ $(v^k - 1)/(v - 1) = (0.1842 - 1)/(0.9346 - 1) = (-0{,}8158)/(-0.0654) = 12.469$ (or obtain from table B-1) 12.469 X 5.0 = 62.3

Step 4: $1/(1 + d)^n = 1/(1 + 0.07)^1 = 0.9346$ (or obtain from table B-4) 0.9346 X 62.3 = 58.2 = $58,200

The PW (as of the base date) of $58,200 is less than 50 percent of the total of all 25 costs in base date dollars (that is, less than 50 percent of $5,000 X 25 or $125,000); this seems to be a reasonable order of magnitude for the conditions of the example.

(3) Example: e positive. The data for a certain cost are: base date cost = $5,000; k = 25 annual payments; d = 10 percent; e = 2 percent; first payment due 3.5 years after ABD. The following steps are illustrated in figure 3-3:

Step 1: Enter input data (as in previous examples).

Step 1					Step 2	Step 3			Step 4	
Annual Costs ☒ $ x 10^3 ☐ $ x 10^6	Years from ABD: First Incurred	Years from ABD: Last Incurred	Total No. of Payments	Annual Cost on ABD	Escalation Factor	Escal. Cost (Time First Incurred): 1st Ann. Cost in Series	Escal. Cost (Time First Incurred): Annual Series Eq Factor	Escal. Cost (Time First Incurred): Equiv. Single Cost	Discount Factor	Present Worth on ABD
Example #1										
e = 0, n = 3.5	3.5	27.5	25	5.0	$(1.0)^{3.5}$ = 1.0	5.0	9.985	49.9	$(\frac{1}{1.1})^{3.5}$ = 0.7164	35.7
Example #2										
e = 0, n = 1	1.0	25.0	25	5.0	$(1.0)^1$ = 1.0	5.0	12.469	62.3	$(\frac{1}{1.1})^{1.0}$ = 0.9441	58.9
Example #3										
e = +0.02, n = 3.5	3.5	27.5	25	5.0	$(1.02)^{3.5}$ = 1.072	5.36	11.668	62.5	$(\frac{1}{1.1})^{3.5}$ = 0.7164	44.8
Example #4										
e = -0.02, n = 3.5	3.5	27.5	25	5.0	$(0.98)^{3.5}$ = 0.9137	4.666	8.656	40.3	$(\frac{1}{1.1})^{3.5}$ = 0.7164	28.9
Example #5										
Elect 1)	3.5	7.5	5	5.0	[illegible]	5.88	4.179	[illegible]	[illegible]	16.1
2)	8.5	17.5	10	5.0	1.2555*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
										45.4
Example #6										
Elect. 1)	1.0	3.0	3	5.0	$(1.0528)^1$	5.26	2.952	15.5	$(\frac{1}{1.07})^1$ = 0.9346	14.5
2)	8.0	8.0	5	5.0	$(1.0528)^4$	6.14	4.504	27.7	$(\frac{1}{1.07})^4$ = 0.7629	21.1
3)	15.0	25.0	17	5.0	[illegible]	6.58	10.888	71.8	[illegible]	39.1
										74.7

$$* \ (1.0528)^3 \times (1.0141)^5 \times (1.0063)^{0.5} = 1.2555$$

Figure 3-3. Annually recurring cost calculations

Step 2: $(1 + e)^n = (1 + 0.02)^{3.5} = 1.072$ [or obtain from table B-3 (after interpolation)] 1.072 X 5.0 = 5.36

Step 3: Obtain the annual series equivalence factor (for 25 payments) of 11.668 from table B-2. Then: 11.668 X 5.36 = 62.5

Step 4: Obtain the discount factor of 0.7164 from table B-4 (after interpolation). Then: 0.7164 X 62.5 = 44.8 = $44,800.

(4) Example: e negative. The data for a certain cost are: base date cost = $5,000; k = 25 annual payments; d = 10 percent; e = -2 percent; first payment due 3.5 years after ABD. The following steps are illustrated in figure 3-3:

Step 1: Enter input data (as in previous examples).

Step 2: $(1 + e)^n = (1 - 0.02)^{3.5} = 0.932$ [or obtain from table B-3 (after interpolation)] 0.932 X 5.0 = 4.66

Step 3: Obtain the annual series equivalence factor (for 25 payments) of 8.656 from table B-2. Then: 8.656 X 4.66 = 40.3

Step 4: Obtain the discount factor of 0.7164 from table B-4 (after interpolation). Then: 0.7164 X 40.3 = 28.9 = $28,900

(5) Example: variable escalation rate: two subseries. A series of 25 annually recurring $5,000 costs (estimated as of the base date of 1 July 1982) is expected to escalate at varying rates, over and above the general inflation rate, as follows:

e_1 = 5.28 percent (base date to 1 Jul 85)
e_2 = 1.41 percent (1 Jul 85 to 1 Jul 90)
e_3 = 0.63 percent (after 1 July 90)

The first annual cost will be incurred on 1 January 1986, or 3.5 years after the base date, and the discount rate is 10 percent. The PW of this series of costs is calculated as follows (the steps are illustrated in figure 3–3):

Step 1: Enter the cost description and cost information for the escalating series. In doing so, note that the first annual cost is incurred after the escalation rate has changed from 5.28 percent to 1.41 percent (that is, at 3.5 years after the base date). Note also that after 5 years (five annual payments) the escalation rate changes again. The series of 25 annual payments may then be considered as two successive subseries. the first subseries consists of five annual payments beginning in 3.5 years after ABD; the first payment of this subseries is escalated for 3.0 years at 5.28 percent and for 0.5 years at 1.41 percent. Succeeding payments in this series are escalated at an additional 1.41 percent. The second subseries consists of 20 annual payments beginning in 8.5 years after ABD; the first payment of this subseries is escalated at 5.28 percent for 3.0 years after the base date, at 1.41 percent for 5.0 years after that, and at 0.63 percent for 0.5 years after that. Succeeding payments are escalated at an additional 0.63 percent. Each of these subseries must be treated separately, and information is entered separately for each on the worksheet.

Step 2: Calculate the escalation factor for the first annual cost of each subseries. For the first subseries, the factor is $(1.0528)^3$ X $(1.0141)^{0.5}$ = 1.1751. Enter this factor, and multiply it by the annual cost at the base date to obtain 1.751 X 5.0 = 5.88 as the escalated cost of the first payment of the first subseries. For the second subseries, the escalation factor is $(1.0528)^3$ X $(1.0141)^5$ X $(1.0063)^{0.5}$ = 1.2555. Enter this factor, and multiply it by the annual cost at the base date to obtain 1.2555 X 5.0 = 6.28 as the escalated first cost for the second subseries.

Step 3: Obtain the annual series equivalence factor for each subseries. For the first subseries, with e_2 = 1.41 percent and k = 5 payments, interpolation between the 1 and 2 percent columns of table B-2 yields a factor of 4.278. [The formula $(v^k - 1)/(v - 1)$ yields $(0.9219^5 - 1)/(0.9219\ \ 1)$ = (- 0.3341)/(- 0.0781) = 4.278 as well.] Enter this factor, and multiply it by the escalated first cost for the first subseries to obtain the equivalent one-time cost (at

3.5 years) of the first subseries as 4.278 X 5.88 = 25.2. With e_3 = 0.0063 and k = 20 payments, interpolation between the O and 1 percent columns of table B-2 gives an annual series equivalence factor of 9.764 and an equivalent one-time cost (at 8.5 years) of 9.764 X 6.28 = 61.3 for the second subseries.

Step 4: Calculate the discount factors for the two subseries as 1/(1 + d)", where d = 0.10, n = 3.5 for the first subseries, and n = 8.5 for the second subseries. Enter these factors, and multiply each by its related equivalent onetime cost, to obtain 0.7164 X 25.2 = 18.1 or $18,100 for the first subseries and 0.4447 X 61.3 = 27.3 or $27,300 for the second subseries. The present worth (at the base date) of the entire 25-year series of annual costs is then the sum $18,100 + 27,300 = $45,400.

(6) Example: variable escalation rate: three subseries. A series of 25 annual $5,000 costs (estimated as of the base date) is expected to escalate at varying rates above the general inflation rate, as follows:

e_1 = 5.28 percent (first 4 years after base date)

e_2 = 1.41 percent (next 5 years)

e_3 = 0.63 percent (all remaining years)

The first annual cost will be incurred 1 year after the base date, and the discount rate is 7 percent. The PW of this series of costs is calculated as follows (the steps are illustrated in figure 3-3):

Step 1: Enter the cost description and cost information for the series. In doing so, note that the timing of the first annual payment and the changes in the escalation rate result in essentially three successive subseries. The first subseries consists of three annual payments beginning at one year after ABD; these payments are escalated at 5.28 percent. The second subseries consists of five annual payments beginning at four years after ABD; the first payment of this subseries is escalated at 5,28 percent for 4 years. Succeeding payments in this subseries are escalated at the rate of 1.41 percent per year. The third subseries consists of the remaining 17 annual payments, beginning at nine years after ABD; the first payment of this subseries is escalated at 5.28 percent for 4 years and 1.41 percent for 5 years, and succeeding payments are escalated at an additional 0.63 percent. Each of these subseries is entered and treated separately.

Step 2: Calculate the escalation factor for the first payment of each subseries as $(1 + 0.0528)^1$ for the first, $(1 + 0.0528)^4$ for the second, and $(1 + 0.0528)^4$ X $(1 + 0.0141)^5$ for the third. Enter these factors, and multiply each by the annual cost at the base date (5.0) to obtain 5.26, 6.14, and 6.59 as the escalated first costs for the three subseries.

Step 3: Obtain the annual series equivalence factor for each subseries by interpolation in table B-1 or with the formula $(v^k - 1)/(v - 1)$. By interpolation for the first subseries, with e = 5.28 percent and k = 3, the factor is 2.952; for the second subseries, with e = 1.41 percent and k = 5, the factor is 4.504; for the third subseries, with e = 0.63 percent and k = 17, the factor is 10.888. Enter these factors, and multiply each by its escalated first cost to obtain the equivalent one-time cost for each subseries (15.5, 27.7, and 71.8, respectively) at the time of the first payment for the subseries.

Step 4: Obtain the discount factor for each subseries as 1/(1 + d)", where d = 0.07 and n is 1 for the first subseries, 4 for the second subseries, and 9 for the third. Discount the equivalent one-time costs to the base date by multiplying each by its discount factor. The results are 15.5 X 0.9346 = 14.5 or $14,500 for the first subseries; 27.7 X 0.7629 = 21.1 or $21,100 for the second subseries; and 71.8 X 0.5439 = 39.1 or $39,100 for the third subseries. The present worth (at the base date) for the entire 25-year series of costs is then the sum $14,500 + $21,100 + $39,100 = $74,700.

3-3. Illustrative analyses.

In this paragraph, the procedures of paragraph 2 above are applied to three typical MCP design alternatives included in an economic analysis for the Central Administration Building at ABCDE Ammunition Plant in Mississippi. The economic life projected for the facility is 25 years. The exterior closure and conventional HVAC calculations in paragraphs a and b below are typical for the HQDA criteria of paragraphs 2-2, 2-5, and 2-6. The solar water heating system calculation in paragraph c below is typical for the FEMP criteria of paragraphs 2-3 and 2-4 when the incremental analysis approach (para 2–4c) is used. Basic input data for each alternative are given to indicate how they enter the calculations. All computations are shown, but they are not discussed. Instead, data and computations are presented on worksheets, as they would be in a complete economic study.

a. Exterior closure. split face block. DA Form 5605-3-R (Life Cycle Cost Analysis-Basic Input Data Summary) Figure 3-4 shows the basic input data for this alternative, and DA Form 5605-4-R (figure 3-5) shows the PW calculations.

(1) *Basic input data.* All cost items are listed on the basic input data summary worksheet, along with information that identifies the project and the alternative. The HQDA criteria of paragraph 2–2 apply here. According to these criteria, the discount rate is 10 percent; the analysis period begins on the DOS and extends to the end of the projected economic life of the facility, 25 years after BOD; and all dates are based on actual projections. These data are entered on the input data summary worksheet. The various available data sources are utilized to develop estimates of the construction and M&R costs for the split face block wall system as of the base date. Finally, a cash flow diagram is sketched on the worksheet DA Form 5605-3-R (fig 3-4). The diagram indicates the timing of all costs connected with the alternative at hand. In particular, according to paragraph 2-2, the ABD is taken to be the DOS (1 January 1982); initial procurement costs are charged at the projected midpoint of construction (1 July 1984); and M&R costs are charged once each year over the 25 year economic life of the facility, with the first expenditure occurring (on 1 July 1985) six months after the projected BOD (on 1 Jan 85).

(2) *Present worth calculations.* The sole one-time cost is the initial investment of $55,400; its PW is calculated using the procedure of paragraph 3-2 b(l). The PW of the annually recurring maintenance and repair cost is calculated according to paragraph 3-2c(1). The calculations are performed and recorded—step by step—on the worksheet in DA Form 5605-4-R (figure 3-5). The results are summarized at the bottom of the worksheet DA Form 5605–4-R.

b. HVAC system. conventional design. DA Form 5605-3-R (fig. 3-6) shows the basic input data for this alternative, and DA Form 5605-4-R (fig. 3-7) shows the PW calculations. The complete LCCA is presented in appendix A, and is discussed in chapter 6.

(1) *Basic input data.* All cost items are listed on the basic input data summary worksheet, along with information identifying the project and the alternative. The HQDA criteria of paragraph 2-2 apply here; these criteria determine the discount rate and the base date, as noted in paragraph 3-3a(1). The analysis period begins on the DOS, and extends to the end of the projected economic life of the facility, 25 years after BOD. These data are entered in DA Form 5605-3-R (fig. 3-6). In accordance with prevailing guidance at the time of the study, differential escalation rates for electricity and fuel oil costs are based on Department of Energy (DOE) projections for the Federal Energy Management Program (FEMP), Commercial Sector, and are determined from tabulated values published in the Federal Register (46 FR 22) and incorporated in the Code of Federal Regulations 10 CFR 436A. The rates used are those projected for DOE Region 4, the appropriate region for a facility in Mississippi (see app c). Cost estimates for all cost categories/elements are developed or constructed from the best available sources. The estimates are entered, and a cash flow diagram is drawn on the worksheet DA Form 5605-3-R (fig 3-6). Also shown on the cash flow diagram are the escalation "time zones," the periods of time during which the various escalation rates will be in effect. Initial costs are charged at the midpoint of construction, and annually recurring costs are charged at the middle of each year after BOD.

(2) *Present worth calculations.* The PWs of the initial procurement costs for the fan system and central plant are calculated in accordance with paragraph 3-2b(l) In addition, the fans will have to be replaced 15 years after BOD (18 years after the base date), and a significant number of central-plant components will require replacement 12 years after BOD. The PWs of the costs of

LIFE CYCLE COST ANALYSIS
BASIC INPUT DATA SUMMARY

For use of this form, see TM 5-802-1; the proponent agency is USACE.

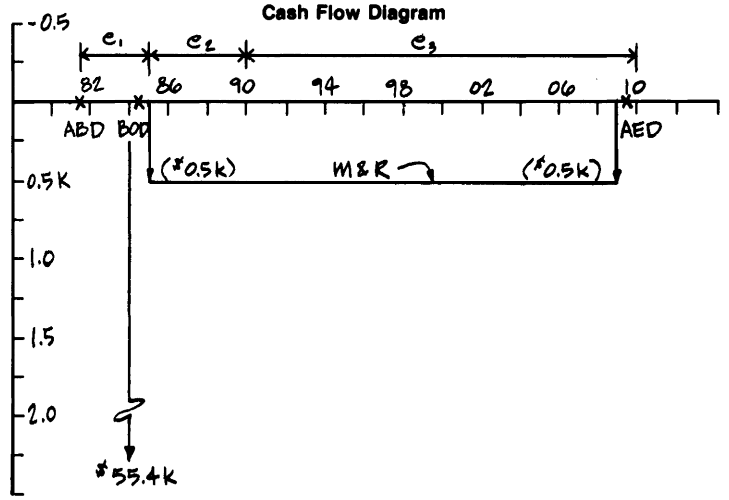
Project No. & Title PN 175 (FY84) Admin. Bldg.
Installation & Location ABCDE Ammo. Plant, Miss.
Design Feature Exterior Closure
Alt. No. A **Title** Split Face Block

Criteria Reference		HQDA
Date of Study (DOS)		1 Jan 82
Analysis Base Date (ABD)		1 Jan 82
Analysis End Date (AED)		1 Jan 10
Midpoint of Construction		1 Jul 84
Beneficial Occupancy Date (BOD)	Actual Projected	1 Jan 85
	Assumed for Analysis	1 Jan 85
DOE Region		4
Annual Discount Rate		10%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: Jul – Jun		
	82-85	85-90	90-10
All	0.00	0.00	0.00

Principal Assumptions

Cash Flow Diagram



Note: Time lines denote 1 Jul of year shown

Cost Element	Cost on ABD ☒ $ x 10³ ☐ $ x 10⁶	Time Cost Incurred** Actual Projected Dates	Dates for Analysis (If Different)*	Source(s) of Data
Initial Investment Cost	55.4	1 Jul 84		Engineer's Project Estimate
M&R	0.5	1 Jul 85 – 1 Jul 09		Eng. Est. – Backup Sheet

DA FORM 5605-3-R, DEC 86

*When 10 CFR436A Criteria Apply
**For Recurring Annual Costs, show date of first and last costs only.

Sheet______ of ______

Figure 3-4. DA Form 5605-3-R, Basic Input Data Summary: Exterior Closure; Split Face Block

Project No. & Title PN 175 (FY84) Admin. Bldg.

Installation & Location ABCDE Ammo. Plant, Miss.

Design Feature Exterior Closure

Alt. No. A Title Split Face Block

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: CONVENTIONAL APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

Criteria Reference	HQDA
Analysis Base Date (ABD)	1 Jan 82
Analysis End Date (AED)	1 Jan 10
Midpoint of Construction	1 Jul 84
BOD for Analysis	1 Jan 85
Annual Discount Rate	10%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: Jul-Jun. 82-85	85-90	90-10
Elect.	5.28	1.41	0.63
Dist. O.	2.52	2.64	6.35
Other	0.00	0.00	0.00

One-Time Costs (☒ $ x 10³ ☐ $ x 10⁶)	Years From ABD	Cost on ABD	Escalation Factor	Escal. Cost (Time Incurred)	Discount Factor	Present Worth on ABD
Initial Investment Cost	2.5	55.4	$(1.0)^{2.5}$	55.4	$\left(\frac{1}{1.1}\right)^{2.5}=0.788$	43.7

Annual Costs (☒ $ x 10³ ☐ $ x 10⁶)	Years from ABD: First Incurred	Last Incurred	Total No. of Payments	Annual Cost on ABD	Escalation Factor	Escal. Cost (Time First Incurred): 1st Ann. Cost in Series	Annual Series Eq Factor	Equiv. Single Cost	Discount Factor	Present Worth on ABD
M&R	3.5	27.5	25	0.5	$(1.0)^{3.5}$	0.5	9.985	5.0	$\left(\frac{1}{1.1}\right)^{3.5}=0.7164$	3.6

	Initial Costs		Energy/Fuel Costs		M&R Costs		Other Costs		Total
Net Present Worth:	43.7	+	0.0	+	3.6	+	0.0	=	47.3

DA FORM 5605-4-R, DEC 86

Sheet____ of ____

Figure 3-5. Present worth: conventional approach: exterior closure; split face block

Project No. & Title FN 175 (FY84) Admin. Bldg.
Installation & Location ABCDE Ammo. Plant, Miss.
Design Feature HVAC System - Conventional
Alt. No. A Title Const. Vol w/ Recip Chiller

LIFE CYCLE COST ANALYSIS
BASIC INPUT DATA SUMMARY

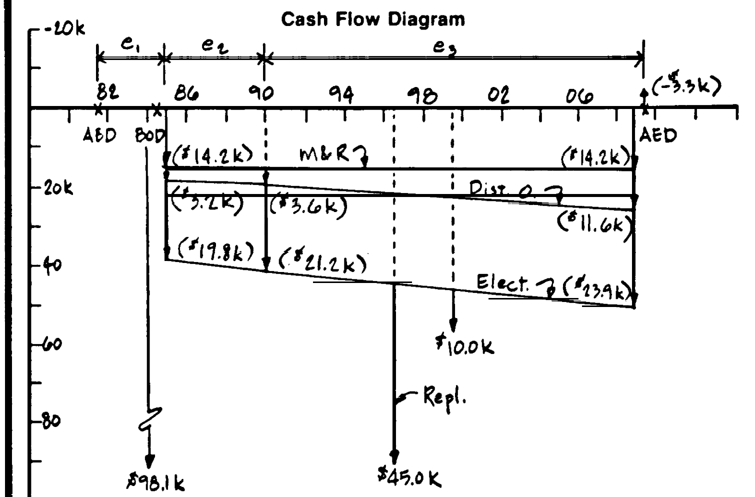
For use of this form, see TM 5-802-1; the proponent agency is USACE.

Criteria Reference		[illegible]
Date of Study (DOS)		1 Jan 82
Analysis Base Date (ABD)		1 Jan 82
Analysis End Date (AED)		1 Jan 10
Midpoint of Construction		1 Jul 84
Beneficial Occupancy Date (BOD)	Actual Projected	1 Jan 85
	Assumed for Analysis	1 Jan 85
DOE Region		4
Annual Discount Rate		10%

Type of Cost	Differential Escalation Rate per Year (%)		
	Timeframe: Jul - Jun		
	82-85	85-90	90-10
Elect.	5.28	1.41	0.63
Dist. O.	2.52	2.64	6.35
Other	0.00	0.00	0.00

Principal Assumptions

Cash Flow Diagram



Note: Time lines denote 1 Jul of year shown

Cost Element	Cost on ABD ☒ $ x 10³ ☐ $ x 10⁶	Time Cost Incurred**		Source(s) of Data
		Actual Projected Dates	Dates for Analysis (If Different)*	
Initial Investment Cost	98.1	1 Jul 84		Engineer's Project Estimate
Replacement (Plant) yr. 12	45.0	1 Jan 97		Eng. Est. – Backup Sheet
Replacement (Fan) yr. 15	10.0	1 Jan 00		Eng. Est. – Backup Sheet
Salvage yr. 25	-3.3	1 Jan 10		Eng. Est. – Backup Sheet
Elect.	16.5	1 Jul 85 - 1 Jul 09		BLAST Program Estimate
Dist. O.	2.9	1 Jul 85 - 1 Jul 09		BLAST Program Estimate
M&R	14.2	1 Jul 85 - 1 Jul 09		Eng. Est. – Backup Sheet

DA FORM 5605-3-R, DEC 86

*When 10 CFR436A Criteria Apply
**For Recurring Annual Costs, show date of first and last costs only.

Sheet ______ of ______

Figure 3-6. DA Form 5605-3-R, Basic Input Data Summary: HVAC System, Conventional these replacements are calculated as in paragraph 3-2b(l). Once the replacements have been installed, the system is expected to have an economic life that extends beyond the analysis period; the system will, therefore, have a net salvage value that should be included in the analysis. The net salvage value is estimated by assuming straight-line depreciation, and the PW of this negative cost is computed in accordance with paragraph 3–2b(l). The PWs of the annually recurring maintenance and repair costs are calculated according to paragraph 3-2c(1). The PWs of the electricity and fuel costs are calculated according to paragraph 3-2c(5) (two subseries). The calculations are performed and summarized as indicated on the worksheet DA Form 5605-4-R (fig. 3-7).

c. Domestic water heating system. solar heating. DA Form 5605-3-R (figure 3–8) shows the basic input data for this "alternative," which represents the solar-energy portion only (i.e., the solar-energy "increment") of the domestic hot water (DHW) system as a whole. DA Form 5605-4-R (fig. 3-9) shows the PW calculations. The complete LCCA, which illustrates the use of the incremental-analysis approach (per para 2-4c) is presented in appendix A, and is discussed in chapter 6.

(1) *Basic input data* All cost items are listed on the basic input data summary worksheet, along with information identifying the project and the (incremental) alternative. In accordance with standard practice (for the incremental-analysis approach), all costs shown represent the incremental costs attributable to the investment under consideration—in this case, the solar-energy system (i.e., the costs attributable to the DHW system with the solar portion incorporated, less the cost attributable to the conventional DHW system without the solar portion incorporated). The FEMP criteria of paragraph 2-4 apply here. The ABD is taken to be 1 July 1981, corresponding to the FEMP-prescribed base date in effect at the time the study was conducted. The discount rate is 7 percent. The analysis period is 25 years, corresponding to the projected economic life of the facility. These data are entered in figure 3-8. The construction midpoint and BOD fall on 1 July 1981 (the ABD). Differential escalation rates for the cost of electricity are those which were prescribed for the Federal Energy Management Program at the time the study was conducted, as indicated in paragraph 1 –4. In accordance with prevailing guidance at the time of the study, the rates were determined from tabulated values, for the Commercial Sector, published in the Federal Register. (Vol. 46, No. 222, 18 Nov 81) and incorporated in the 1982 edition of the Code of Federal Regulations (Title 10, Part 436, Subpart A). The rates used are those for DOE Region 4, the appropriate region for a facility in Mississippi (Appendix C). Cost estimates for all categories/elements are developed or constructed from the best available sources. The estimates, along with the aforementioned data, are entered on the worksheet DA Form 5605-3-R (fig 3-8), and a cash flow diagram is constructed. Initial investment costs, which are reduced by 10 percent (to provide the statutorily-required 10 percent investment credit for energy-saving design initiatives), are charged on the ABD, and annually recurring costs are charged at the end of each year after BOD.

(2) *Present worth calculations.* The PW of the incremental initial investment cost (less the 10 percent investment credit) is calculated according to the procedure described in paragraph 3-2b(l). The PW of the incremental M&R cost is calculated by the method of paragraph 3-2c(2), and the PW of the electricity y-cost savings by the method of paragraph 3-2c(6) (three subseries). The results of the PW calculations are summarized at the bottom of the worksheet DA Form 5605-4-R (fig 3-9).

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: CONVENTIONAL APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

Project No. & Title PN 175 (FY84) Admin. Bldg.
Installation & Location ABCDE Ammo. Plant, Miss.
Design Feature HVAC System — Conventional
Alt. No. A Title Const. Vol. w/ Recip. Chiller

One-Time Costs ☒ $ x 10³ ☐ $ x 10⁶	Years From ABD	Cost on ABD	Escalation Factor	Escal.Cost (Time Incurred)	Discount Factor	Present Worth on ABD
Initial Investment Cost	2.5	98.1	$(1.0)^{2.5}$	98.1	$(\frac{1}{1.1})^{2.5} = 0.788$	77.3
Replacement-Plant yr. 12	15.0	45.0	$(1.0)^{15}$	45.0	$(\frac{1}{1.1})^{15} = 0.239$	10.8
Replacement-Fan yr. 15	18.0	10.0	$(1.0)^{18}$	10.0	$(\frac{1}{1.1})^{18} = 0.180$	1.8
Salvage yr. 25	28.0	-3.3	$(1.0)^{28}$	-3.3	$(\frac{1}{1.1})^{28} = 0.069$	-0.2

Criteria Reference	HQDA
Analysis Base Date (ABD)	1 Jan 82
Analysis End Date (AED)	1 Jan 10
M	84
BOD A	J 85
Annual Discount Rate	10%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: Jul - Jun 82-85	85-90	90-10
Elect.	5.28	1.41	0.63
Dist. O.	2.52	2.64	6.35
Other	0.00	0.00	0.00

Annual Costs ☒ $ x 10³ ☐ $ x 10⁶	Years from ABD: First Incurred	Last Incurred	Total No. of Payments	Annual Cost on ABD	Escalation Factor	Escal.Cost (Time First Incurred): 1st Ann. Cost in Series	Annual Series Eq Factor	Equiv. Single Cost	Discount Factor	Present Worth on ABD
Elect. ① 85-89	3.5	7.5	5	16.5	$(1.0528)^{3.5}$	19.8	4.278	84.7	$(\frac{1}{1.1})^{3.5} = 0.7164$	60.7
② 90-09	8.5	27.5	20	16.5	$(1.0528)^{3.5}(1.0141)^{5}$	21.2	9.768	207.0	$(\frac{1}{1.1})^{8.5} = 0.4448$	92.1
Dist. O. ① 85-89	3.5	7.5	5	2.9	$(1.0252)^{3.5}$	3.2	4.375	14.0	0.7164	10.0
② 90-09	8.5	27.5	20	2.9	$(1.0252)^{3.5}(1.0252)^{5}$	3.6	14.805	53.3	0.4448	23.7
M&R	3.5	27.5	25	14.2	$(1.0)^{3.5}$	14.2	9.985	141.8	0.7164	101.6

Net Present Worth:	Initial Costs		Energy/Fuel Costs		M&R Costs		Other Costs		Total
	77	+	187	+	102	+	12	=	378

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Sheet ____ of ____

Figure 3-7. DA Form 5605-4-R Present worth: conventional approach: HVAC system, conventional

Project No. & Title PN 175 (FY 84) Admin. Bldg.
Installation & Location ARCPE Ammo. Plant, Miss.
Design Feature Domestic Hot Water Heating System
Alt. No. B-A Title Solar System Increment

LIFE CYCLE COST ANALYSIS
BASIC INPUT DATA SUMMARY

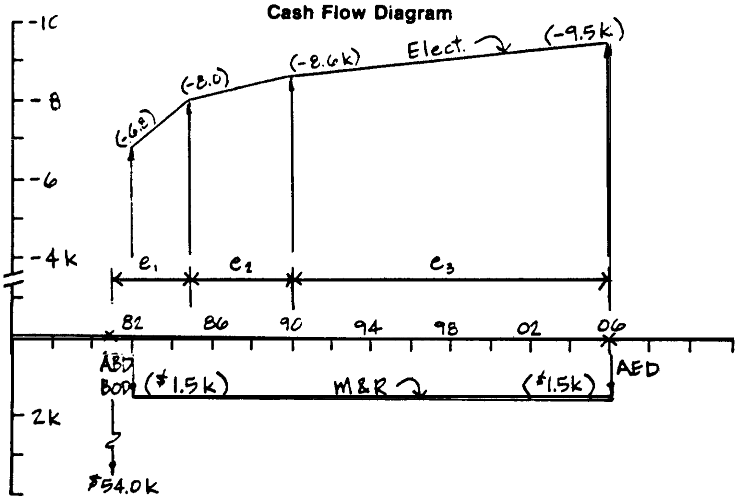
For use of this form, see TM 5-802-1; the proponent agency is USACE.

Criteria Reference		FEMP
Date of Study (DOS)		1 Jan 82
Analysis Base Date (ABD)		1 Jul 81
Analysis End Date (AED)		1 Jul 06
Midpoint of Construction		N.A.
Beneficial Occupancy Date (BOD)	Actual Projected	1 Jan 85
	Assumed for Analysis	1 Jul 81
DOE Region		4
Annual Discount Rate		7%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: Jul – Jun		
	81-85	85-90	90-06
Elect.	5.28	1.41	0.63
Other	0.00	0.00	0.00

Principal Assumptions

Cash Flow Diagram



Note: Time lines denote 1 Jul of year shown

Cost Element	Cost on ABD ☒ $ x 10³ ☐ $ x 10⁶	Time Cost Incurred** Actual Projected Dates	Time Cost Incurred** Dates for Analysis (If Different)*	Source(s) of Data
Initial Investment Cost	54.0 (60.0 less 10%)	1 Jul 84	1 Jul 81	Engineer's Project Estimate
Elect.	-6.5	Jul 85 - 1 Jul 09	1 Jul 82 - 1 Jul 06	Eng. Est. – Backup Sheet
M&R	1.5	Jul 85 - 1 Jul 09	1 Jul 82 - 1 Jul 06	Eng. Est. – Backup Sheet

DA FORM 5605-3-R, DEC 86

*When 10 CFR436A Criteria Apply
**For Recurring Annual Costs, show date of first and last costs only.

Sheet ____ of ____

Figure 3-8. DA Form 5605-3-R Basic input data summary: domestic hot water heating system; solar system increment.

Project No. & Title FN 175 (FY 84) Admin. Bldg.

Installation & Location ABCDE Ammo. Plat, Miss.

Design Feature Domestic Hot Water Heating System

Alt. No. B-A Title Solar System Increment

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: CONVENTIONAL APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

Criteria Reference	FEMP
Analysis Base Date (ABD)	1 Jul 81
Analysis End Date (AED)	1 Jul 06
Midpoint of Construction	N.A.
BOD for Analysis	1 Jul 81
Annual Discount Rate	7%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: Jul - Jun 81-85	85-90	90-06
Elect.	5.28	1.41	0.63
Other	0.00	0.00	0.00

One-Time Costs (☒ $ x 10³ ☐ $ x 10⁶)	Years From ABD	Cost on ABD	Escalation Factor	Escal. Cost (Time Incurred)	Discount Factor	Present Worth on ABD
Initial Investment Cost	0	54.0	$(1.0)^0$	54.0	$(\frac{1}{1.07})^0 = 1.0$	54.0

Annual Costs (☒ $ x 10³ ☐ $ x 10⁶)	Years from ABD: First Incurred	Last Incurred	Total No. of Payments	Annual Cost on ABD	Escalation Factor	Escal. Cost (Time First Incurred): 1st Ann. Cost in Series	Annual Series Eq Factor	Equiv. Single Cost	Discount Factor	Present Worth on ABD
Elect. (1) 82-84	1.0	3.0	3	-6.5	$(1.0528)^1$	-6.8	2.952	-20.1	0.9346	-18.8
(2) 85-89	4.0	8.0	5	-6.5	$(1.0528)^4$	-8.0	4.504	-36.0	0.7629	-27.5
(3) 90-06	9.0	25.0	17	-6.5	$(1.0528)^4(1.0141)^5$	-8.6	10.888	-93.6	0.5439	-50.9
M&R	1.0	25.0	25	1.5	$(1.0)^1$	1.5	12.469	18.7	0.9346	17.5

Net Present Worth: Initial Costs 54.0 + Energy/Fuel Costs -97.2 + M&R Costs 17.5 + Other Costs 0.0 = Total -25.7

DA FORM 5605-4-R, DEC 86

Sheet ____ of ____

Figure 3-9. DA Form 5605-4-R Present worth: conventional approach: domestic hot water heating system; solar system increment.

CHAPTER 4

PRESENT WORTH CALCULATIONS: ONE-STEP APPROACH

4-1. Introduction.

The one-step approach to present worth calculations is an alternative to the conventional approach covered in chapter 3. Its greatest advantage is simplicity. In the conventional approach, for example, it is necessary to represent each recurring annual fuel/energy cost series by several subseries. Not only are separate PW calculations required for each of these subseries (for each fuel/energy type), but in addition the number of payments in the cost series that; fall into each "escalation time zone", the date on which the first payment in each time zone is incurred, and the time between that date and the ABD must be calculated. In the one-step approach, the subseries representation is not required, thus eliminating the need for all these extra calculations. In addition, the number of table lookups, interpolations, and multiplications for each PW calculation is reduced significantly in the one-step approach. All that is required for each PW calculation-in essence—is a single table lookup to determine a single factor—the one-step adjustment factor *(OSAF)* or simply the *adjustment factor.* Tables of adjustment factors ("one-step" tables) for all of the commonly occurring types of costs encountered in MCP applications-i. e., for one-time costs with a zero differential escalation rate, for annually recurring costs with a zero differential escalation rate, and for annually recurring energy/fuel costs with differential escalation rates projected by the DOE (for FEMP applications)–have been developed, and are available by request, through normal channels, to HQDA (DAEN-ECE-G), WASH, DC 20314-1000. These tables will be updated and kept current, as required (e.g., each time the DOE develops and publishes revised differential escalation rates for fuel and energy prices for FEMP, and The Office of the Secretary of Defense authorizes/directs their adoption for DoD applications). *(Sample* one-step tables are provided in this chapter, where they are used in conjunction with the examples presented.) In any situation that is not covered by the one-step tables, the conventional approach of chapter 3 may be used. The scope and applications of the one-step approach are illustrated in this chapter. In paragraph 4-2 the approach is outlined and used to find the PWS of some of the same general types of costs as are covered in paragraph 3-2. In paragraph 4-3 the approach is used to apply the criteria of chapter 2 to the same MCP design alternatives that are treated in paragraph 3-3. The examples in these paragraphs point up both the ease of application of the one-step approach and its major disadvantage: the procedure is so simplified that there may be a loss of sensitivity to the significance of PW calculations and their results. All simulated case histories presented in this chapter were developed in January 1982, and all utilize cost information that generally reflects market prices and cost growth of that time frame (see para 1-4). (It should be noted that the uniform-present-worth (UPW) factors for M&R costs and the modified uniform-present-worth (UPW*) factors for fuel/energy costs provided for in the FEMP criteria are in essence non-normalized OSAFs. These are readily converted to OSAFs by dividing them by the number of payments in the series, or number of years in the study period.)

4-2. Calculations.

In the one-step approach, the PW for any cost element is obtained as the product of a *nominal total cost* for that element and a tabulated *one-step adjustment factor*, corrected as necessary with a *DOS correction factor.* (The nominal cost, adjustment factor, and correction factor are defined below.) With regard to frequency of occurrence, all costs are classified as either one-time costs or annually recurring costs. The general calculational approaches for the two types of costs are very similar in nature.

a. Classification of costs for calculations. As discussed in more detail in paragraph 3-2a, the costs related to construction projects and design elements may be considered to be of four types with respect to frequency of occurrence: one-time costs, cyclical costs, annually recurring costs, and continuous costs. By convention, in determining present worths, a cyclical cost is treated as a series of one-time costs; similarly, the amounts incurred for a continuous cost are summed over each 12-month period, and the sum is treated as an annually recurring cost. These conventions reduce the number of cost frequency types to two. However, three separate sets of tables of one-step adjustment factors are required to calculate the PWs of these two types of costs, as follows:

–Tables for one-time costs.

–Tables for annually recurring costs other than energy/fuel costs (e.g. M&R).

–Tables for annually recurring energy/ fuel costs.

The need for three distinct sets of tables stems from the varying requirements of the criteria of chapter 2. In fact, the tables are formulated for use with specific criteria—either HQDA criteria or FEMP criteria-and will be updated as these criteria change. However, all the tables are used in approximately the same way in the one-step approach.

b. Calculations for one-time costs. The present worth (on the analysis base date (ABD)) of a one-time cost (in base date dollars) is calculated as follows:

Step 1: Estimate the amount of the one-time cost as of the base date, and the time at which it will occur.

Step 2: Use the appropriate adjustment factor (from the appropriate one-step table) to determine the PW of the cost on the base data.

Each factor in one-step tables for one-time cost (fig 4-1 for example) is the ratio of the actual PW of a one-time cost at the ABD (taking into account cost growth, if any, and the time value of money) to the nominal value of that one-time cost (ignoring cost growth and the time value of money), both expressed in constant ABD dollars. The significance of this factor is best understood when it is viewed as a percentage of the nominal cost. For example, a factor of 0.7513 indicates that the actual PW of the one-time cost in question (on the ABD) is approximately 75 percent of the nominal value of that one-time cost. Initial investment cost factors are generally high. Later replacement cost factors are lower. Salvage-related factors are very low. (Normally, adjustment factors do not exceed 1.0 ·(100 percent) although they can in unusual situations.) The procedure given above simply requires that the pertinent ratio be found in the tables and then multiplied by the nominal cost—which here is the cost as of the base date. The examples that follow illustrate this procedure for typical cases. Those in subparagraph (1) deal with one-time costs to be incurred prior to the BOD (but after the DOS), and those in subparagraph (2) with one-time costs to be incurred after the BOD. These examples are followed (in subpara (3)) by a short discussion on the treatment of special cases not covered by the one-step table. The data and calculations for the examples are organized on a sample worksheet (figure 4-2) taken from the full worksheet, and results are rounded to an appropriate number of significant figures. The full worksheet is DA Form 5605-5-R (Life Cycle Cost Analysis—Present Worth: One-Step Approach), and use of the full worksheet is illustrated in paragraph 4-3 and in chapter 6. DA Form 5605-5-R will be used for present worth calculation by conventional approach.

(1) Example: pre-BOD cost, e = 0. A cost of $13,500 in 1 January 1982 dollars (or $13,000 in 1 July 1981 dollars) is expected to be incurred on 1 January 1985, 3 years after the DOS of 1 January 1982. The BOD is projected to be 1 July 1985. The cost is not expected to escalate at a rate greater than the general inflation rate. The adjustment factor for this cost depends on the applicable criteria—that is, on whether the analysis is being conducted according to HQDA criteria (para 2-2, 2-5, and 2–6) or FEMP criteria (para 2-3 and 2-4).

(a) HQDA criteria and methodology. In an analysis conducted according to HQDA criteria, the ABD is taken to be 1 January 1982 (the DOS). The PW of this cost is found as follows (the steps are illustrated in figure 4-2):

Step 1: Enter a brief description of the cost, the number of years from the base date of 1 January 1982 to cost incurrence (3), and the $13,500 estimate of the cost at the base date. Check the appropriate box to indicate the dollar magnitude, or leave the boxes blank to denote "no multiplier."

Step 2: Obtain the adjustment factor from the HQDA criteria column of one-step table 1 (fig 4-l). The factor for "3 years after ABD" is 0.7513. Enter this factor, and then multiply it by the base date cost to obtain a PW of 0.7513 x 13.5 = 10.1 or $10,100 as of the base date.

(b) FEMP criteria and methodology. In an analysis conducted according to FEMP criteria, the ABD and BOD are taken to be 1 July 1981 (the FEMP-prescribed base date) and all costs incurred in that timeframe (between the ABD and the BOD) are assumed to have been incurred on that date. The amount of the cost as of this date is $13,000. Its PW is found as follows —(the steps are illustrated in fig 4-2):

ALL REGIONS

ONE TIME COSTS

ONE STEP ADJUSTMENT FACTORS

FEMP METHODOLOGY		HQDA METHODOLOGY	
TIME COST INCURRED (YEARS AFTER AUD)	PER FEMP CRITERIA <1>	TIME COST INCURRED (YEARS AFTER AUD)	PER HQDA CRITERIA <2>
0.	1.0000	0.	1.0000
1.0	0.9346	1.0	0.9091
2.0	0.8734	2.0	0.8264
3.0	0.8163	3.0	0.7513
4.0	0.7629	4.0	0.6830
5.0	0.7130	5.0	0.6209
6.0	0.6663	6.0	0.5645
7.0	0.6227	7.0	0.5132
8.0	0.5820	8.0	0.4665
9.0	0.5439	9.0	0.4241
10.0	0.5083	10.0	0.3855
11.0	0.4751	11.0	0.3505
12.0	0.4440	12.0	0.3186
13.0	0.4150	13.0	0.2897
14.0	0.3878	14.0	0.2633
15.0	0.3624	15.0	0.2394
16.0	0.3387	16.0	0.2176
17.0	0.3166	17.0	0.1978
18.0	0.2959	18.0	0.1799
19.0	0.2765	19.0	0.1635
20.0	0.2584	20.0	0.1486
21.0	0.2415	21.0	0.1351
22.0	0.2257	22.0	0.1228
23.0	0.2109	23.0	0.1117
24.0	0.1971	24.0	0.1015
25.0	0.1842	25.0	0.0923
26.0	0.1722	26.0	0.0839
27.0	0.1609	27.0	0.0763
28.0	0.1504	28.0	0.0693
29.0	0.1406	29.0	0.0630
30.0	0.1314	30.0	0.0573
35.0	0.0937	35.0	0.0356
40.0	0.0668	40.0	0.0221
45.0	0.0476	45.0	0.0137
50.0	0.0339	50.0	0.0085
0.25	0.9832	0.25	0.9765
0.50	0.9667	0.50	0.9535
0.75	0.9505	0.75	0.9310

NOTES

<1> FIGURES BASED ON 7% DISCOUNT RATE
<2> FIGURES BASED ON 10% DISCOUNT RATE

Figure 4-1. Adjustment factors for one-time costs (one-step table 1).

Step 1			Step 2	
One-Time Costs ☒ $ x 10³ ☐ $ x 10⁶	Years from ABD	Cost On ABD	One Step Adj.Factor Table 1	Present Worth on ABD
Example #1				
Pre-BOD, e = 0				
(a) HQDA	3	13.5	0.7513	10.1
(b) FEMP	0	13.0	1.0000	13.0
Example #2				
Post BOD, e = 0				
(a) HQDA	15	3.0	0.2394	0.72
(b) FEMP	11.5	2.9	0.4593	1.3

Figure 4-2. One-time cost calculations.

Step 1: Enter the input data (as above). Note that the number of years from ABD is zero, in accordance with the FEMP criteria for all costs incurred prior to BOD.

Step 2: Obtain the adjustment factor from the FEMP criteria column of one-step table 1 (fig 4-1). The factor for "0 years after ABD" is 1.0. Enter this factor, and then multiply it by the base date cost of $13,000 to obtain a PW of 1.0 x 13.0 = 13.0 or $13,000 as of the base date.

(2) Example: post-BOD cost, e = 0. A cost of $3,000 in 1 January 1982 dollars (or $2,880 in 1 July 1981 dollars) is expected to be incurred on 1 January 1997, 15 years after the date of study of 1 January 1982 and 11.5 years after the BOD, which is projected to be 1 July 1985. The cost is not expected to escalate at a greater rate than the general inflation rate. Again, the PW of this cost depends on the applicable criteria (HQDA or FEMP).

(*a*) *HQDA criteria and methodology*. In an analysis conducted according to HQDA criteria, the ABD is taken to be 1 January 1982 (the DOS). The PW of this cost is determined as follows (the steps are illustrated in fig 4-2):

Step 1: Enter the input data, including the cost of $3,000 as of the base date.

Step 2: Obtain the adjustment factor from the HQDA criteria column of one-step table 1 (fig 4-1). Here the factor is 0.2394. Enter this factor; then multiply it by the base date cost to obtain a PW of 0.2394 x 3.0 = 0.72 or $720 as of the base date.

(*b*) *FEMP criteria and methodology*. In an analysis conducted according to FEMP criteria, the ABD and BOD are taken to be 1 July 1981 (the FEMP prescribed base date). The amount of the cost as of this date is $2,880 or approximately $2,900. According to FEMP criteria, the cost is assumed to be incurred on 1 January 1993 (11.5 years after the ABD), the date on which it would have been incurred had the BOD actually occurred on the ABD. Its PW is obtained as follows (the steps are illustrated in fig 4-2):

Step 1: Enter the input data (as above).

Step2: Obtain the adjustment factor from the FEMP criteria column of figure 4-1. The factor for 11.5 years is 0.4593-the factor for 11 years, 0.4571, multiplied by the factor for 0.5 years, 0.9667, near the bottom of the table. (Note that straight-line interpolation in fig 4-1, between 11 years and 12 years, gives a slightly less accurate, but perfectly acceptable, value of 0.4596.) Enter this factor, and multiply it by the base date cost to obtain a PW of 0.4593 X 2.9 = 1.3 or $1,300 as of the base date.

(3) One-time cost situations not covered by the one-step table. The one-step table for one-time costs will not provide adjustment factors for the following cases:

– One-time cost situations in which the differential escalation rate is positive, negative, or variable (that is, situations in which e # O).
– Situations in which the cost at hand is to be incurred more than 50 years after the analysis base date.

The conventional approach of paragraph 3-2b may be used in all such cases. See, for example, paragraphs 3-2b(2) and (3).

c. Calculations for annually recurring costs. The general form of a series of uniformly escalating annual costs is shown in figure 3-2. The present worth (on the base date) of such a series of costs is found as follows:

Step 1: Estimate the amount A_0 of the annually recurring cost as of the base date, and determine the number of costs k in the series.

Step 2: Determine the *nominal total cost* as A_0k. Obtain the appropriate adjustment factor and correction factor from the appropriate one-step table and determine the PW of the series of costs by multiplying the nominal total cost by these factors.

Each adjustment factor in the one-step tables for annually recurring costs, M&R or energy (figs 4-3, 4-4 or 4-5 for example), is a ratio of the actual PW of a series of annually recurring costs at the ABD (taking into account cost growth, if any, and the time value of money) to the nominal total cost of the series (ignoring cost growth and the time value of money), both expressed in constant ABD dollars. The significance of this factor is best understood when it is viewed as a percentage of the nominal total cost. For example, a factor of 0.4661 indicates that the actual PW of the series of annually recurring costs is about 47 percent of the value of the nominal total cost of that series. The one-step adjustment factors for annually recurring costs are tabulated based on the assumption that the ABD corresponds to the most recent FEMP-directed base date (as prescribed in 10 CFR 436A). For all analyses governed by the FEMP criteria (see para 2-3 and 2-4), the assumption is automatically valid, and the tabulated factor is used directly. For all analyses governed by the HQDA criteria, however (see para 2-2, and 2-5), the assumption must be considered to be invalid, since in these types of analyses the ABD is set to correspond to the date of the study (DOS), and the DOS normally occurs after the FE MP-prescribed base date. Accordingly, in these types of analyses, the tabulated adjustment factors must be corrected—to account for the difference in time between the FEMP-directed base date and the DOS. Fortunately, the correction is a simple one to make, and the correction factors to be used are readily available. In fact, each of the one-step tables for annually recurring costs contains the correction factor that is appropriate for the data in that particular table. (Refer to the DOS correction factor at the bottom of the table.) The examples that follow illustrate the use of the one-step approach for PW calculations for several typical cases. Those in subparagraph (1) deal with annual costs for which e = O (e.g., M&R costs, in general), and those in subparagraph (2) deal with annual fuel/energy costs, for which e values are specifically prescribed. The data and calculations for each example are organized on a sample worksheet (fig 4-6), and results are rounded to an appropriate number of significant figures. The full worksheet is DA Form 5605-5-R, and use of the full worksheet is illustrated in paragraph 4-3 and in chapter 6.

(1) Example: e = 0. An annually recurring cost which is estimated as $5,000 (in constant ABD dollars) will be incurred each year for the 25-year projected economic life of the facility. The cost is not expected to escalate at a rate greater than the general inflation rate (e = O). The date of the study (DOS) is 1 January 1982, and the BOD is projected to be 1 January 1985. The PW of this series of costs depends on the applicable criteria—that is, on whether the analysis is being conducted according to HQDA (para 2-2, 2-5, and 2-6) or FEMP criteria (para 2-3 and 2-4).

ALL REGIONS

MAINTENANCE AND REPAIR (M&R) <4>

ONE STEP ADJUSTMENT FACTORS

ANALYSIS PERIOD (NUMBER OF) (PAYMENTS)	<1> PER FEMP	BENEFICIAL OCCUPANCY DATE — PER HQDA AS PROJECTED <2>								
	1 JUL 81	1 JUL 83	1 JUL 84	1 JUL 85	1 JUL 86	1 JUL 87	1 JUL 88	1 JUL 89	1 JUL 90	1 JUL 91
10	0.7024	0.5326	0.4842	0.4402	0.4002	0.3638	0.3307	0.3006	0.2733	0.2485
15	0.6072	0.4395	0.3996	0.3632	0.3302	0.3002	0.2729	0.2481	0.2255	0.2050
20	0.5297	0.3690	0.3354	0.3049	0.2772	0.2520	0.2291	0.2083	0.1893	0.1721
25	0.4661	0.3147	0.2861	0.2601	0.2364	0.2150	0.1954	0.1776	0.1615	0.1468
30	0.4136	0.2724	0.2476	0.2251	0.2046	0.1860	0.1691	0.1537	0.1398	0.1271
50	0.2760	0.1719	0.1563	0.1420	0.1291	0.1174	0.1067	0.0970	0.0882	0.0802
DATE-OF-STUDY CORRECTION FACTOR	---	1.008 PER MONTH AFTER 1 JUL 81 <2> <3>								

NOTES

<1> FIGURES BASED ON 7% DISCOUNT RATE AND END-OF-YEAR CONVENTION
<2> FIGURES BASED ON 10% DISCOUNT RATE AND MIDDLE-OF-YEAR CONVENTION
<3> UNCORRECTED ADJUSTMENT FACTORS BASED ON ASSUMED BOS OF 1 JUL 81
<4> ADJUSTMENT FACTORS BASED ON ASSUMED DIFFERENTIAL ESCALATION RATE OF 0%

Figure 4-3. Adjustment factors for annually recurring M&R costs (one-step table 2).

REGION 4

ONE STEP ADJUSTMENT FACTORS

ELECTRICITY

ANALYSIS PERIOD (NUMBER OF) (PAYMENTS)	<1> PER FEMP	BENEFICIAL OCCUPANCY DATE — PER HQDA AS PROJECTED <2>								
	1 JUL 81	1 JUL 83	1 JUL 84	1 JUL 85	1 JUL 86	1 JUL 87	1 JUL 88	1 JUL 89	1 JUL 90	1 JUL 91
10	0.8517	0.6671	0.6184	0.5701	0.5237	0.4808	0.4410	0.4041	0.3699	0.3384
15	0.7554	0.5598	0.5175	0.4763	0.4372	0.4011	0.3677	0.3368	0.3083	0.2820
20	0.6700	0.4751	0.4387	0.4035	0.3703	0.3396	0.3112	0.2850	0.2608	0.2386
25	0.5970	0.4084	0.3769	0.3465	0.3179	0.2915	0.2671	0.2446	0.2239	0.2048
30	0.5348	0.3555	0.3279	0.3014	0.2765	0.2535	0.2323	0.2127	0.1947	0.1781
50	0.3650	0.2268	0.2091	0.1921	0.1762	0.1615	0.1480	0.1355	0.1240	0.1135
DATE-OF-STUDY CORRECTION FACTOR	---	1.0037 PER MONTH AFTER 1 JUL 81 <2> <3>								

NOTES

<1> FIGURES BASED ON 7% DISCOUNT RATE AND END-OF-YEAR CONVENTION
<2> FIGURES BASED ON 10% DISCOUNT RATE AND MIDDLE-OF-YEAR CONVENTION
<3> UNCORRECTED ADJUSTMENT FACTORS BASED ON ASSUMED DOS OF 1 JUL 81

Figure 4-4. Adjustment factors for annually recurring electricity costs (one-step table 3.4EL).

REGION 4

ONE STEP ADJUSTMENT FACTORS

DISTILLATE OIL

ANALYSIS PERIOD (NUMBER OF) (PAYMENTS)	<1> PER FEMP	BENEFICIAL OCCUPANCY DATE — PER HQDA AS PROJECTED <2>								
	1 JUL 81	1 JUL 83	1 JUL 84	1 JUL 85	1 JUL 86	1 JUL 87	1 JUL 88	1 JUL 89	1 JUL 90	1 JUL 91
10	0.8005	0.6331	0.5966	0.5643	0.5358	0.5106	0.4886	0.4695	0.4529	0.4379
15	0.7563	0.5700	0.5408	0.5145	0.4909	0.4697	0.4507	0.4338	0.4188	0.4049
20	0.7292	0.5212	0.4962	0.4735	0.4529	0.4341	0.4172	0.4019	0.3881	0.3752
25	0.7091	0.4803	0.4582	0.4380	0.4195	0.4027	0.3873	0.3732	0.3605	0.3485
30	0.6925	0.4448	0.4249	0.4067	0.3899	0.3745	0.3604	0.3474	0.3356	0.3245
50	0.6416	0.3383	0.3240	0.3108	0.2985	0.2871	0.2766	0.2668	0.2578	0.2492
DATE-OF-STUDY CORRECTION FACTOR	---	1.0059 PER MONTH AFTER 1 JUL 81 <2> <3>								

NOTES

<1> FIGURES BASED ON 7% DISCOUNT RATE AND END-OF-YEAR CONVENTION
<2> FIGURES BASED ON 10% DISCOUNT RATE AND MIDDLE-OF-YEAR CONVENTION
<3> UNCORRECTED ADJUSTMENT FACTORS BASED ON ASSUMED DOS OF 1 JUL 81
<4> ADJUSTMENT FACTORS BASED ON ASSUMED DIFFERENTIAL ESCALATION RATE OF 0%

Figure 4-5. Adjustment factors for annually recurring distillate oil costs (one-step table 3.4DO).

Step 1 Step 2

Annual Costs ☒ $ x 10^3 ☐ $ x 10^6	Total No. of Payments	Annual Cost on ABD	Total Nominal Cost on ABD	One Step Adjustment Factor* Table Factor x DOS Correction	Present Worth on ABD
Example #1					
e = 0					
(a) HQDA	25	5.0	125.0	$0.2731 \times (1.008)^6$	35.8
(b) FEMP	25	5.0	125.0	0.4661	58.3
Example #2					
e = variable					
(a HQDA	25	5.0	125.0	$0.3465 \times (1.0037)^{12}$	45.3
(b) FEMP	25	5.0	125.0	0.5970	74.6

* Use one-step table 2, figure 4-3, for example 1;
use one-step table 3, figure 4-4, DOE region 4 (electricity) for example 2.

Figure 4-6. Annually recurring cost calculations.

(a) *HQDA criteria and methodology.* In an analysis conducted according to HQDA criteria, the PW of the annually recurring series of costs is calculated as follows (the steps are illustrated in fig 4-6):

Step 1: Enter a brief description of the cost, the annual cost amount A_0 estimated as of the base date, and the number of annual costs k in the series. Check the appropriate box to indicate the dollar magnitude, or leave the boxes blank to indicate "no multiplier."

Step 2: Compute the nominal total cost as $A_0k = 5.0 \times 25 = 125.0$, and enter it. Interpolate between the 1 July 1984 and 1 July 1985 columns in the HQDA section of figure 4-3 to obtain the adjustment factor for the BOD of 1 January 1985. For k = 25 payments, this factor is 0.2601 + (1/2) (0.0260) = 0.2731; enter the factor. Obtain the correction factor as 1.008 raised to a power equal to the number of months between the first day of the FEMP base year as listed in table 2 (here, 1 July 1981) and the analysis base date (here, 1 January 1982). Since there are 6 months between these dates, the correction factor is (1.008)6. Compute the required PW as nominal total cost X adjustment factor X correction factor to obtain 125 X 0.2731 X $(1.008)^6$ = 35.8 or $35,800 as the PW (as of the base date) of the series of annually recurring costs.

This PW of $35,800 is very close to the $35,700 calculated using the conventional approach in paragraph 3-2c(1). (The difference of $100 is due to "rounding" of the results of calculations in the conventional method—specifically in the calculation of the equivalent single cost.)

(b) FEMP criteria and methodology. In an analysis conducted according to FEMP criteria, the PW of the annually recurring series of costs is obtained as follows (the steps are illustrated in fig 4-6):

Step 1: Enter input data (as above).

Step 2: Compute the nominal total cost as A_0k = 5.0 X 25 = 125, and enter it. Obtain the adjustment factor from the FEMP column of figure 4-3. For k = 25 payments, the adjustment factor is 0.4661; enter this factor. (There is no DOS correlation under the FEMP criteria, as indicated in the tables, and the tabulated factor is used directly.) Compute the PW as nominal total cost X adjustment factor to obtain 125 X 0.4661 = 58.3 or $58,300 as the PW (as of the base date) for the series of annually recurring costs.

This PW of $58,300 is very close to the $58,200 calculated using the conventional approach in paragraph 3-2c(2). (As in para 4-2c(l)(a), the difference is due to rounding-here again, in the calculation of the equivalent single cost.)

(2) Example: e variable. An annually recurring cost, which is estimated as $5,000 (in constant ABD dollars), will be incurred each year over the 25-year projected economic life of the facility. This cost is expected to escalate at the differential rates disseminated by HQDA and incorporated into the applicable energy-cost adjustment factors for electricity for DOE Region 4. The DOS is 1 July 1982, and the BOD is projected to be 1 July 1985. The PW of this series of costs depends on the applicable criteria (HQDA or FEMP).

(a) HQDA criteria and methodology. In an analysis conducted according to HQDA criteria, the PW of the series of costs is calculated as follows (the steps are illustrated in fig 4-6):

Step 1: Enter input data (as in previous examples).

Step 2: Compute the nominal total cost as A_0k = 5.0 X 25 = 125.0, and enter it. Obtain the adjustment factor from the 1 July 1985 column in the HQDA sections of fig 4-4. This factor is 0.3465; enter it on the worksheet. Obtain the correction factor as 1.0037 raised to a power equal to the number of months between 1 July 1981 and the date of study, 1 July 1982. Since the DOS follows 1 July 1981 by 12 months, the correction factor is (1.0037)12 = 1.045; enter this factor. Compute the required PW as nominal total cost X adjustment factor X correction factor to obtain 125 X 0.3465 X 1.045 = 45.3 or $45,300 as the PW (as of the base date) of the series of annually recurring costs.

This PW of $45,300 is very close to the $45,400 found with the conventional approach in paragraph 3-2c(5). (The slight difference is due to separate upward rounding of the PWs, to get to three significant figures, for each of the two subseries calculated by the conventional approach.)

(b) FEMP criteria and methodology. In an analysis conducted according to FEMP criteria, the PW of the annually recurring series of costs is obtained as follows (the steps are illustrated in fig 4-6):

Step 1: Enter input data (as in previous examples).

Step 2: Compute the nominal total cost as A_0k = 5.0 X 25 = 125, and enter it. Obtain the adjustment factor from the FEMP column of figure 4-4. Here, the adjustment factor is 0.5970; enter this factor. (There is no DOS correction under the FEMP criteria, as indicated in the tables, and the tabulated factor *is* used directly.) Compute the PW as nominal total cost X adjustment factor to obtain 125 X 0.5970 = 74.6 or $74,600 as the PW (as of the base date) for the series of costs.

This PW of $74,600 is very close to the $74,700 obtained with the conventional approach in paragraph 3-2c(6). Note the comparative ease with which it was computed. (The slight difference is due to the use of linear interpolation in table B-2 to obtain the annual series equivalence factors in paragraph 3-2c(6). The function tabulated, shown beneath the tabulated data, is clearly non-linear.)

(3) Annually recurring costs. Situations not covered by one-step tables. One-step tables for annually recurring costs will cover those cases where the value of e is assumed to be zero (fig

4-3, for example) and those cases where the value of e is assumed to vary as specified by the latest version of FEMP criteria (fig 4-4 and 4-5, for example). When these values of e are not applicable to a particular situation, PWs may be computed using the conventional approach of paragraph 3-2c. See, for example, paragrah 3-2c(3).

4-3. Illustrative analyses.

In this paragraph the procedures of paragraph 4-2 are applied to three typical MCP design alternatives included in an economic study for the Central Administration Building at ABCDE Ammunition Plant in Mississippi. The economic life projected for the facility is 25 years. The same alternatives are treated using the conventional approach in paragraph 3-3, so the two approaches can easily be compared. Since the basic input data are the same for both approaches, the input data worksheets of paragraph 3-3 are not repeated here. Only the one-step calculations are shown, organized on worksheets as they would be in a complete economic study. The one-step adjustment factors presented on the worksheets are taken from figure 4-1, figure 4-3, figure 4-4 or figure 4-5 either directly or by interpolation, as appropriate, The PWs developed with the one-step approach are equal for all practical purposes to those calculated by means of the conventional approach (para 3-3). The minor differences derive from rounding and interpolations from tabulated data.

a. Exterior closure. split face block. Figure 3-4 shows the basic input data for this alternative, and DA Form 5605-5-R (fig 4-7) shows the one-step PW calculations.

–Basic input data. See paragraph 3-3a(1) and figure 3-4.

—Present worth calculations. The sole one-time cost is the initial investment of $55,400; its PW is found with the procedure of paragraph 4-2 b(l)(a). The PW of the annually recurring maintenance and repair cost is calculated according to paragraph 4-2c(1)(a). The pertinent data and factors are recorded on the worksheet in figure 4-7; the multiplications are performed; and the results are summarized at the bottom of the worksheet.

b. HVAC system: conventional design. Figure 3-6 shows the basic input data for this alternative, and figure 4-8 shows the one-step PW calculations. The complete LCCA is discussed in chapter 6.

(1) Basic input data. See paragraph 3-3b(l) and figure 3-6.

(2) Present worth calculations. The PWs of the initial investment costs for the fan system and central plant are found with the procedure of paragraph 4-2 b(l)(a). In addition, the fans will have to be replaced 15 years after BOD, and a significant number of central plant components will require replacement 12' years after BOD. The PWs of the costs of these replacements are calculated as explained in paragraph 4-2b(2)(a). Once the replacements have been installed, the system is expected to have an economic life that extends beyond the analysis period. The system will, therefore, have a net salvage value that should be included in the analysis. The net salvage value is estimated by assuming straight-line depreciation, and the PW of this negative one-time post-BOD cost is computed in accordance with paragraph 4-2b(2)(a). The PWs of the annually recurring maintenance and repair costs are found as in paragraph 4-2c(l)(a), The PWs of the electricity and fuel costs (the one-step adjustment factors for distillate oil are shown in fig 4-5) are found in accordance with paragraph 4-2c(2)(a). The data and results are recorded and summarized as shown on the worksheet DA form 5605-5-R (fig 4-8).

c. Domestic water heating system: solar heating. Figure 3-8 shows the basic input data for this “alternative”, which represents the solar-energy portion only (i.e., the solar-energy "increment") of the domestic hot water (DHW) system as a whole. Figure 4-9 shows the PW computations. The complete LCCA, which illustrates the use of the incremental-analysis approach (per para 2-4c) is presented in appendix A, and is discussed in chapter 6.

(1) *Basic input data.* See paragraph 3-3c(1) and figure 3-8.

(2) *Present worth calculations.* The PW of the incremental initial investment cost (less the 10 percent investment credit) is found with the procedure of paragraph 4-2b(l)(b), since FEMP criteria (para 2-4) apply here. The PW of the incremental M&R cost is calculated according to paragraph 4-2c(l)(b), and the PW of the electricity cost savings according to paragraph 4-2c(b). The results of the calculations are summarized at the bottom of the worksheet DA Form 5605-5-R (fig 4-9):

Project No. & Title PN 175 (FY84) Admin. Bldg.
Installation & Location ABCDE Ammo. Plant, Miss.
Design Feature Exterior Closure
Alt. No. A Title Split Face Block

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: ONE-STEP APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

One-Time Costs [X] $ x 10³ [ ] $ x 10⁶	Years from ABD	Cost On ABD	One Step Adj.Factor Table 1	Present Worth on ABD
Initial Investment Cost	2.5	55.4	0.7880	43.7

Criteria Reference	HQDA
Analysis Base Date (ABD)	1 Jan 82
Analysis End Date (AED)	1 Jan 10
Midpoint of Construction	1 Jul 84
BOD for Analysis	1 Jan 85
Annual Discount Rate	10%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: Jul - Jun 82-85	85-90	90-10
All	0.00	0.00	0.00

Annual Costs [X] $ x 10³ [ ] $ x 10⁶	Total No. of Payments	Annual Cost on ABD	Total Nominal Cost on ABD	One Step Adjustment Factor* Table Factor x DOS Correction	Present Worth on ABD
M&R	25	0.5	12.5	$0.2731 \times (1.008)^6$	3.6

	Initial Costs		Energy/Fuel Costs		M&R Costs		Other Costs		Total
Net Present Worth:	43.7	+	0.0	+	3.6	+	0.0	=	47.3

DA FORM 5605-5-R, DEC 86

*Use One-Step Table 2 for M&R costs (e = 0).
Use One-Step Table 3 for energy/fuel costs (e = prescribed e value). Sheet____ of____

Figure 4-7. DA Form 5605-5-R, Present worth: one-step approach: exterior closure, split face block

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: ONE-STEP APPROACH

Project No. & Title PN 175 (FY84) Admin. Bldg.
Installation & Location ABCDE Ammo. Plant, Miss.
Design Feature HVAC System — Conventional
Alt. No. A Title Const. Vol w/ Recip. Chiller

For use of this form, see TM 5-802-1; the proponent agency is USACE.

One-Time Costs [X] $ x 10³ [ ] $ x 10⁶	Years from ABD	Cost On ABD	One Step Adj.Factor Table 1	Present Worth on ABD
Initial Investment Cost	2.5	98.1	0.7880	77.3
Replacement - Plant yr. 12	15.0	45.0	0.2394	10.8
Replacement - Fan yr. 15	18.0	10.0	0.1799	1.8
Salvage yr. 25	28.0	-3.3	0.0693	-0.2

Criteria Reference	HQDA
Analysis Base Date (ABD)	1 Jan 82
Analysis End Date (AED)	1 Jan 10
Midpoint of Construction	1 Jul 84
BOD for Analysis	1 Jan 85
Annual Discount Rate	10%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: Jul-Jun 82-85	85-90	90-10
Elect.	5.28	1.41	0.63
Dist. O.	2.52	2.64	6.35
Other	0.00	0.00	0.00

Annual Costs [X] $ x 10³ [ ] $ x 10⁶	Total No. of Payments	Annual Cost on ABD	Total Nominal Cost on ABD	One Step Adjustment Factor* Table Factor x DOS Correction	Present Worth on ABD
Elect.	25	16.5	412.5	$0.3617 \times (1.0037)^6$	152.5
Dist. O.	25	2.9	72.5	$0.4481 \times (1.0059)^6$	33.7
M&R	25	14.2	355.0	$0.2731 \times (1.008)^6$	101.7

	Initial Costs		Energy/Fuel Costs		M&R Costs		Other Costs		Total
Net Present Worth:	77	+	186	+	102	+	12	=	377

DA FORM 5605-5-R, DEC 86

*Use One-Step Table 2 for M&R costs (e = 0).
Use One-Step Table 3 for energy/fuel costs (e = prescribed e value).

Sheet_____ of_____

Figure 4-8. DA Form 5605-5-R Present worth: one-step approach: HVAC system, conventional.

Project No. & Title PN 175 (FY84) Admin. Bldg.
Installation & Location ABCDE Ammo. Plant, Miss.
Design Feature Domestic Hot Water Heating System
Alt. No. B-A Title Solar System Increment

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: ONE-STEP APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

One-Time Costs [X] $ x 10³ [ ] $ x 10⁶	Years from ABD	Cost On ABD	One Step Adj. Factor Table 1	Present Worth on ABD
Initial Investment Cost	0	54.0	1.0	54.0

Criteria Reference	FEMP
Analysis Base Date (ABD)	1 Jul 81
Analysis End Date (AED)	1 Jul 06
Midpoint of Construction	N.A.
BOD for Analysis	1 Jul 81
Annual Discount Rate	7%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: Jul-Jun 81-85	85-90	90-06
Elect.	5.28	1.41	0.63
Other	0.00	0.00	0.00

Annual Costs [X] $ x 10³ [ ] $ x 10⁶	Total No. of Payments	Annual Cost on ABD	Total Nominal Cost on ABD	One Step Adjustment Factor* Table Factor x DOS Correction	Present Worth on ABD
Elect.	25	-6.5	-162.5	0.5970	-97.0
M&R	25	1.5	37.5	0.4661	17.5

	Initial Costs		Energy/Fuel Costs		M&R Costs		Other Costs		Total
Net Present Worth:	54.0	+	-97.0	+	17.5	+	0.0	=	-25.5

DA FORM 5605-5-R, DEC 86

*Use One-Step Table 2 for M&R costs (e = 0).
Use One-Step Table 3 for energy/fuel costs (e = prescribed e value).

Sheet ______ of ______

Figure 4-9. DA Form 5605-5-R Present worth: one-step approach: domestic hot water heating system, solar system increment.

CHAPTER 5

ECONOMIC RANKING CALCULATIONS

5-1. Introduction.

Each set of criteria in paragraphs 2-2 through 2-6 specifies a method by which economic rankings are to be assigned to design alternatives. The various ranking criteria are similar in nature and are, for the most part, based on the net LCCs of the alternatives. There are, however, sufficient differences so that it is worthwhile to present, in the paragraphs that follow, brief demonstrations of the application of the criteria and related calculations. With the exception of the discounted payback period determination-which typically require two to four iterations—the calculations are relatively simple and straightforward.

5-2. General economic studies.

Ranking criteria for general economic studies are presented in paragraph 2-2c. Criteria for uncertainty assessment are cited in paragraph 2-2b(9). The examples described in subparagraphs *a* through k below and outlined in table 5-1, illustrate the application of these criteria to the results of LCC calculations. All LCC figures cited below are net LCCs—i.e., the difference between the PWs of all costs and the PWs of all monetary benefits.

a. Example 1, LCC results clearly conclusive. The LCC of alternative B is 50 percent greater than that of alternative A. The LCC results are thus clearly conclusive, so that uncertainty assessment is not required (para 2-2b(9)). Alternative A is ranked higher than alternative B on the basis of LCC alone (para 2–2c(l)); neither initial costs nor fuel/energy consumption enters into the ranking procedure.

b. Example 2, LCC results clearly inconclusive. The LCCs of alternatives C and D are essentially equal. The LCC results are thus clearly inconclusive, so that uncertainty assessment is not required (para 2–2b(9)). Neither alternative can be ranked higher on the basis of LCC alone, so ranking must be based on the tie-breaking criteria of paragraph 2–2c(2). Alternative D is ranked higher because it is lower in initial cost and will consume no more fuel/energy than alternative C.

c. Example 3, LCC results clearly inconclusive. The LCCs of alternatives E and F are essentially equal. The LCC results are thus clearly inconclusive, so uncertainty assessment is not required. Ranking must be based on the tie-breaking criteria of paragraph 2-2c(2). Alternative F is ranked higher because it will consume less fuel/energy than alternative E and will be no more expensive in terms of initial cost.

d. Example 4, LCC results clearly inconclusive. The LCCs of alternatives G and H are essentially equal. The LCC results are therefore clearly inconclusive, so uncertainty assessment is not required. Ranking must be based on the tie-breaking criteria of paragraph 2-2c(2). Before these criteria can be applied, the annual fuel/energy consumption of the two alternatives must be converted to Btu equivalents, as shown in table 5-1. Then, alternative H is assigned the higher ranking because it will consume at least 15 percent less fuel/energy than alternative G and will be less than 15 percent higher in initial cost.

e. Example 5, LCC results clearly inconclusive. The LCCs of alternatives I and J are essentially equal. The LCC results are therefore clearly inconclusive, so uncertainty assessment is not required. Ranking must be based on the tie-breaking criteria of paragraph 2-2c(2). Alternative I is assigned the higher ranking because it will be at least 15 percent less expensive than alternative J in terms of initial cost and will consume less than 15 percent more fuel/energy per year.

f. Example 6, LCC results clearly inconclusive. The LCCs of alternatives K and L are essentially equal. The LCC results are therefore clearly inconclusive, so uncertainty assessment is not required. Ranking must be based on the tie-breaking criteria of paragraph 2-2c(2). Since none of the specific (listed) criteria of that paragraph are satisfied, the two alternatives are assigned the same ranking. The designer would then select, for use in the facility, the alternative which represents the best overall choice in his or her judgment. Here, alternative K would most likely be selected, owing to its lower net LCC and annual fuel/energy consumption.

g. Example 7, LCC results not clear-cut. The LCC results are neither clearly inconclusive nor clearly conclusive. An uncertainty assessment' would be required by the criteria of paragraph 2-2b(9) if the design decision were not a routine one. However, alternative M ranks higher by the criteria of both paragraph 2–2c(1) and paragraph

2-2c(2), so the relative rankings of the two alternatives cannot be affected by the results of an uncertainty assessment. Hence, no uncertainty assessment is needed (para 2–2b(9)), and alternative M is ranked higher.

h. Example 8, LCC results not clear-cut. The LCC results are neither clearly inconclusive nor clearly conclusive. Uncertainty assessment is not required by paragraph 2-2b(9) because this is a routine design decision (see "Notes" column in table 5-l). In such a case, in the absence of an uncertainty-assessment determination, alternative O may be ranked higher on the basis of LCC alone (para 2-2c(1)).

i. Example 9, LCC results not clear-cut. The LCC results are neither clearly conclusive nor clearly inconclusive. Uncertainty assessment is required by paragraph 2-2b(9) because the design decision is not a routine one (the choice of alternative Q is likely to be controversial). Relative rankings then are based on the uncertainty assessment results and the criteria of paragraph 2-2c, as follows:

(1) *High uncertainty.* If the uncertainty assessment shows uncertainty in the LCC results to be high (HI in table 5-l), the LCC results are definitely not conclusive. The LCCs of the alternatives are considered to be comparable, and alternative R is ranked higher according to the first tie-breaking criterion of paragraph 2-2c(2).

(2) *Low uncertainty.* If the uncertainty assessment shows uncertainty to be low (LO in table 5-l), the LCC results are definitely conclusive. Alternative Q is ranked higher on the basis of its lower net LCC (para 2–2c(1)).

(3) *Medium uncertainty.* If the uncertainty assessment shows uncertainty to be in the medium range (MED in table 5-l), the LCC results are neither definitely conclusive or definitely inconclusive. Ranking is then left to the designer's judgment, based on all pertinent factors. In this case, the designer would most likely assign the higher ranking to alternative R, based on its lower initial cost and annual fuel/energy consumption.

j. Example 10, LCCs not determined. If an LCCA has not been conducted, alternatives are to be ranked solely on the basis of initial cost considerations (para 2-2c(l)). Alternative S, with the lower initial cost, is thus assigned the higher ranking.

k. Example 11, LCC results not clear-cut. The LCC results are neither clearly inconclusive nor clearly conclusive, and the design decision is not a routine one (headquarters approval is required). Moreover, in contrast to the situation of subparagraph g above, the alternative with the lower apparent LCC would not be ranked higher according to the tie-breaking criteria of paragraph 2-2c(2), since it has the higher initial cost and annual fuel/energy consumption. Thus, an uncertainty assessment is required by paragraph 2-2b(9). Since the required uncertainty assessment was not performed, the LCCA was not conducted in strict accordance with paragraph 2-2, and rankings must be assigned solely on the basis of initial cost considerations (para 2-2c(1)). Accordingly, alternative V is assigned the higher ranking, based on its lower initial cost.

5-3. Special energy-conservation studies: non-renewable resources.

The ranking criterion for these studies is given in paragraph 2-3c. Ranking is based strictly on net LCC: The alternative with the lowest net LCC is assigned the highest economic ranking, and so on down to the alternative with the greatest net LCC, which is assigned the lowest ranking. If two alternatives have equal or nearly equal net LCCs, they are assigned the same ranking. In a case in which two or more alternatives are tied for the highest ranking, selection should be based on designer's judgment as to which of these alternatives is the best overall choice for the application at hand. Accordingly, in the situation in which alternative A is the most economical of the feasible conventional alternatives, and in which

Net LCC of conventional alternative A = 96.5×10^3 (in ABD $)

Net LCC of energy-saving alternative B = 110×10^3

Net LCC of energy-saving alternative C = 97×10^3,

alternatives A and C, which have nearly equal LCCs, would be tied for the highest rank. Alternative B would be ranked lowest. The designer would select either alternative A or alternative C based on his or her judgment as to which is the best overall choice for the application-in terms of initial cost as well as energy consumption.

5-4. Special energy-conservation studies: renewable resources.

The ranking criteria for these studies are given in paragraph 2-4c. In the absence of special ranking requirements beyond those of the FEMP, the economic rankings of alternatives in the LCCA may be determined and reported in either absolute terms or relative terms. The prescribed measure for determining rankings in absolute

Table 5-1. General Economic Studies Ranking Examples

Example No.	Alternative	LCC (ABD $ x 10^3)	Initial Costs (ABD $ x 10^3)	Average Annual Fuel/Energy Consumed	Degree of Uncertainty* in LCC Results (HI, MED, LO): From Uncertainty Assessment	Degree of Uncertainty* in LCC Results (HI, MED, LO): Judgment Only	Notes
1	A	40.0	35.0	More than Alt. B		LO	
	B	60.0	20.0	Less than Alt. A			
2	C	35.0	25.9	Essentially Equal		HI	
	D	35.4	24.5				
3	E	35.0	25.0	13,000 KWH		HI	
	F	35.4	24.8	11,500 KWH			
4	G	35.0	25.0	13,000 KWH = 151 x 10^6 Btu		HI	
	H	35.4	27.7	122,200 ft^3 NG = 126 x 10^6 Btu			
5	I	35.0	25.0	13,000 KWH		HI	
	J	35.4	29.8	12,000 KWH			
6	K	35.0	25.0	12,000 KWH		HI	
	L	35.4	24.5	13,000 KWH			
7	M	44.0	35.0	Essentially Equal		MED	
	N	45.8	40.0				
8	O	44.0	31.2	Essentially Equal		MED	Routine design decision
	P	45.8	30.0				
9	Q	44.0	31.2	13,000 KWH	(a) HI	-	Selection of Alt. Q likely to be controversial
	R	45.8	30.0	12,000 KWH	(b) LO (c) MED		
10	S	Not Determined	19.0	10,200 KWH		-	
	T		20.5	6,000 KWH			
11	U	44.0	31.2	13,000 KWH	Not Determined	MED	Deviation from criteria--head quarters approval required
	V	45.8	30.0	12,000 KWH			

*Uncertainty assessment results HI, LO, MED are defined as follows.

- HI: LCC results shown are definitely not conclusive; LCCs are essentially equal.
- LO: LCCA results shown are definitely conclusive.
- MED: LCCA results are neither definitely conclusive nor definitely inconclusive.

The terms conclusive and inconclusive are defined in paragraph 2-2c(1).
See also paragraph 2-2b(9).

terms is net LCC; criteria to be used in conjunction with this measure are provided in paragraph 2-3*c* and illustrated in paragraph 5-3. The prescribed measure for determining rankings in relative terms is LCC savings. However, two additional relative-ranking measures—the savings-to-investment ratio (SIR) and the discounted payback period (DPP)—may have to be determined in response to special requirements. (All four ranking measures provide the same results in a specific LCCA; that is, an alternative that is ranked most economical in terms of net LCC would also be ranked most economical in terms of LCC savings, SIR, and DPP.) The criteria to be used in conjunction with the three relative-ranking measures are provided in paragraph 2-4*c* and illustrated below. The computation and application of LCC savings are illustrated in paragraph 5-4*a*; the SIR is computed and applied in paragraph 5-4*b*; and the DPP is computed and applied in paragraph 5-4*c*. In the illustrations, a proposed hypothetical energy-saving design, based on the use of a renewable source of energy (like solar energy), will be ranked in comparison with an hypothetical conventional design, representing the most economical design based on the use of fossil-fuel-derived energy only. In accordance with standard practice, the conventional design will be referred to as the baseline alternative (or system) and the energy-saving design as the investment, or the investment alternative (or system)—in the sense that the additional initial costs required for the energy-saving design represent an investment, which will yield a return in terms of cost avoidance for energy consumption.

a. Net LCC savings. The net LCC savings is equal to the net LCC of the baseline alternative less the net LCC of the proposed energy-saving design (ESD).

(1) Example: positive net LCC savings. If the net LCC savings is positive, then the ESD is considered to be cost effective. Accordingly, in the situation in which

Net LCC of baseline system =	$280.0 X 10^3 (in ABD $)
Net LCC of ESD =	$258.4 X 10^3
Net LCC savings =	$ 21.6 X 10^3

the ESD is cost effective and must be incorporated in the facility.

(2) Example: negative net LCC savings. If the net LCC savings is negative, then the ESD is considered to be not cost effective. In the situation in which

Net LCC of baseline system =	$280.0 X 10^3 (in ABD $)
Net LCC of ESD =	$298.0 X 10^3
Net LCC savings =	-$18.0 X 10^3

the ESD is not cost effective and may not be incorporated in the facility.

(3) Example: net LCC savings at or very near zero. If the net LCC savings is equal to zero, or very nearly equal to zero, then the ESD is to be considered neither cost effective nor not cost effective. Accordingly, in the situation in which

Net LCC of baseline system =	$280.0 X 10^3 (in ABD $)
Net LCC of ESD =	$279.8 X 10^3
Net LCC savings =	$ 0.2 x 10^3

the ESD is neither cost effective nor not cost effective. In this situation the designer should decide whether or not to incorporate the ESD in the facility, based on his or her judgment as to the better overall choice for the application at hand.

b. Savings-to-investment ratio.

(1) Calculation and application. The SIR is computed from the PWs of the costs attributable to the ESD and the baseline alternative, as follows:

Step 1: Determine the PW of the net savings due to the ESD. To do so, algebraically subtract the PWs of all operating and maintenance type costs for the ESD from those for the baseline alternative.

Step 2: Determine the extra investment required for the ESD. To do so, algebraically subtract the PWs of all investment, replacement, net salvage, and other capital costs for the baseline alternative from those for the ESD.

Step 3: Form the ratio of the result of step 1 to the result of step 2. This ratio is the SIR.

As indicated previously, the SIR and net-LCC-savings ranking measures are not independent. The SIR will be greater than 1.0 whenever the net LCC savings is positive, less than 1.0 whenever the net LCC savings is negative, and exactly equal to 1.0 whenever the net LCC savings is exactly equal to zero. Accordingly, the energy-saving design will be cost-effective whenever the SIR is clearly greater than 1.0, not cost-effective whenever the SIR is clearly less than 1.0, and neither cost-effective nor not-cost-effective whenever the SIR is equal to—or very nearly equal to–1.0.

(2) Example: SIR calculation. The computations are organized on a sample worksheet and results are rounded to an appropriate number of significant figures. The full worksheet is DA Form 5605-1-R, (Life Cycle Cost Analysis' Savings-To-Investment Ratio (SIR) and Discounted Payback Calculation). It is assumed that the PWs of all the costs related to the conventional alternative and to the ESD have been computed in accordance with the provisions of paragraph 2-4b by the techniques illustrated in chapters 3 and/or 4), and that the results are available. (This is the usual case.) The SIR is calculated from these PWs as follows (the steps are illustrated in fig 5-1):

Step 1: Enter the PWs of all operating and maintenance costs, including fuel/energy costs, for the baseline system, and find their total. Here, this total is 199.5. Do the same for the investment system (the ESD); the total for this system is 152.9. Subtract the investment-system total from the baseline-system total to obtain the PW savings of 199.5 – 152.9 = 46.6. Enter that figure.

Step 2: Enter the PWs of all capital costs (including initial, replacement, and terminal costs) for the baseline system, and find their total; here, the total is 80.5. Do the same for the investment system; that total is 105.5. Subtract the baseline-system total from the investment-system total to obtain the extra PW investment as 105.5 - 80.5 = 25.0. Enter that figure.

Step 3: Divide the net savings by the extra investment to obtain 46.6/25.0 = 1.9 as the SIR for the investment system (ESD).

Because this SIR is clearly greater than 1.0, the investment is considered cost effective, and the ESD must be incorporated in the facility.

SIR Calculation				
Element of Calculation	**System**	**Type of Cost/Benefit**		
PW of Operating & Maintenance Costs ☒ $ x 10³ ☐ $ x 10⁶	Base-line	Energy/Fuel	125.1	Step 1
		Other O&M	74.4	
		Total	199.5	
	Invest-ment	Energy/Fuel	70.2	
		Other O&M	82.7	
		Total	152.9	
	Δ	Net Savings	46.6	
PW of Capital Costs ☒ $ x 10³ ☐ $ x 10⁶	Base-line	Initial (MCP)	77.2	Step 2
		Replacements Yr 18	3.4	
		Terminal	-0.1	
		Other	–	
		Total Net	80.5	
	Invest-ment	Initial (MCP)	95.5	
		Replacements	10.1	
		Terminal	-0.1	
		Other	–	
		Total Net	105.5	
	-Δ	Extra Investment	25.0	
SIR	Δ	Net Savings / Extra Investment	46.6 / 25.0 = 1.9	Step 3

Figure 5-1: Example: SIR calculation.

c. Discounted payback period. The discounted payback period is the number of years required to recoup an investment through the net savings it provides, with the time value of money and cost escalation (if any) taken into account. For economic studies involving energy-saving designs (e.g., solar), paragraph 2-4c defines the DPP as that period of time, measured in years from the BOD, which, if used as the analysis period for the LCCA, would result in a net PW savings of zero. An equivalent definition is the following The DPP is the number of years, measured from the BOD, which, if used as the analysis period for the LCCA, would result in an SIR of 1.0. The DPP calculation procedure outlined below is based on this latter definition. It is an iterative (trial-and-error) procedure in which a trial analysis period is first computed, and then a SIR is computed for that trial period. If the SIR is not equal to 1.0, a new trial analysis period is computed (based on the previous results) and a new SIR is found. This process is repeated until a SIR of 1.0 is obtained. Normally, no more than about two to four iterations are required. In these calculations, net salvage values (or terminal values) which arise due to the variation of the trial analysis period are usually ignored. However, if their magnitude is expected to be large enough to alter the results of the computation, they must be taken into account. Net salvage values are usually approximated for this purpose based on an assumption of straight-line depreciation.

(1) Calculation and application. The DPP for an energy-saving investment is calculated as follows:

Step 1: Compute the SIR for the energy-saving design (ESD) by the method of paragraph 5-4b, using an analysis period selected in accordance with the provisions of paragraph 2-3b(3).

Step 2: Use the SIR computed in step 1 and the corresponding analysis period (i.e., the criteria-based analysis period) to compute a trial analysis period n, in years (for which it is hoped that the SIR will equal 1.0).

Step 3: Compute the SIR as in Step 1, using an analysis period equal to the trial analysis period n computed in step 2.

Step 4: If the SIR resulting from step 3 is equal to, or very nearly equal to 1.0, stop. The trial analysis period n is the DPP. If not, use the result of step 3 to compute a new trial' n.

Step 5: Repeat steps 3 and 4 until a particular trial value n results in a SIR that is equal to, or very nearly equal to 1.0. The DPP is that particular trial value n.

As indicated previously, the DPP and the net-LCC-savings ranking measures are not independent. The DPP will be less than the criteria-based analysis period whenever the net LCC savings is positive,. greater than the criteria-based analysis period whenever the net LCC savings is negative, and exactly equal to the criteria-based analysis period whenever the net LCC savings is exactly equal to zero. Accordingly, the energy-saving design will be cost-effective whenever the DPP is clearly less than the criteria-based analysis period, not cost-effective whenever the DPP is clearly greater than the criteria-based analysis period, and neither cost-effective nor not-cost-effective whenever the DPP is equal to—or very nearly equal to—the criteria-based analysis period.

(2) *Example: DPP calculation*. The computations are organized on a sample worksheet and results are rounded to an appropriate number of significant figures. The full worksheet is DA Form 5605-1-R. It is assumed here that the PWs of all costs have been computed in accordance with the provisions of paragraph 2-4b (by the techniques illustrated in chap 3 or 4), and that the results are available. (This is the usual case.) The DPP is computed as follows (the steps are illustrated in DA Form 5605-1-R fig 5-2):

Step 1: The SIR for this 'example was computed in paragraph 5-4b(2). The computation is shown on the SIR-DPP worksheet DA Form 5605-1-R (fig 5-2).

Step 2: (The first trial value n is computed directly below the SIR calculation. For this first computation, both the last trial value n and the last SIR are assumed to be zero. "This n" is the analysis period selected in accordance with the provisions of criteria—here, 25 years.) Follow the steps listed on the worksheet to compute the first trial value n, as follows:

A = this SIR - 1.0 = 1.9 - 1.0 = 0.9

B = this SIR – last SIR = 1.9 - 0 = 1.9

C = ratio of A to B = 0.9/1.9 = 0.47

D = last n - this n= 0 - 25= – 25

E = product of C and D = 0.47 x(-25)= –11.8

F = next n = this n+E = 25 +(-11.8) = 13.2

Round this result to 13 for use as the next trial n; enter n = 13 at the top of the first DPP column in the right-hand block.

Step 3: (first iteration): Compute a SIR based on PW data computed over a trial analysis period of 13 years (instead of the original criteria-based value of 25 years). New PWs must be found for operating and maintenance costs; PWs of initial costs do not change; only replacement costs that are expetted to occur within the first

SIR Calculation				Discounted Payback Calculation				
				Trial Values of Post-BOD Analysis Period, n(years)				
Element of Calculation	System	Type of Cost/Benefit		n = 13	n =	n = 7	n =	n = 10
PW of Operating & Maintenance Costs ☒ $\$ \times 10^3$ ☐ $\$ \times 10^6$	Base-line	Energy/Fuel	125.1	65.1		35.0		50.1
		Other O&M	74.4	38.7		20.8		29.8
		Total	199.5	103.8		55.8		79.9
	Invest-ment	Energy/Fuel	70.2	36.5		19.7		28.1
		Other O&M	82.7	43.0		23.2		33.1
		Total	152.9	79.5		42.9		61.2
	Δ	Net Savings	46.6	24.3		12.9		18.7
PW of Capital Costs ☒ $\$ \times 10^3$ ☐ $\$ \times 10^6$	Base-line	Initial (MCP)	77.2	77.2		77.2		77.2
		Replacements	3.4	0		0		0
		Terminal	–	–		–		–
		Other	–	–		–		–
		Total Net	80.6	77.2		77.2		77.2
	Invest-ment	Initial (MCP)	95.5	95.5		95.5		95.5
		Replacements Yr 18	10.1	0		0		0
		Terminal	–	–		–		–
		Other						
		Total Net	105.6	95.5		95.5		95.5
	−Δ	Extra Investment	25.0	18.3		18.3		18.3
SIR	Δ	Net Savings / Extra Investment	46.6 / 25.0 = 1.9	18.3 = 1.3		9 / 18.3 = 0.7		8 / 18.3 = 1.0

Next Trial n Value (Years)							
	A = This SIR — 1.0	0.9	0.3		-0.3		
	B = This SIR — Last SIR*	1.9	-0.6		-0.6		
	C = Ratio of A to B	0.47	-0.5		0.5		
	D = Last n* — This n	-25	12		6		
	E = Product of C & D	-11.8	-6		3		
	F = Next n = This n + E	13.2	7		10		

Step 1

Step 2 (First Iteration)

Step 3 (Second Iteration)

Step 3 (Third Iteration)

Step 4 (First Iteration)

Step 4 (Second Iteration)

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*In calculating First Trial n Value for Discounted Payback Calculation, Use Last SIR = Last n = 0.

Figure 5-2: Example: DPP calculation

13 years after BOD are included; it is assumed that PWs of terminal costs will not affect the results and so they are ignored. The result is a SIR of 1.3.

Step 4: (first iteration): Since the SIR is not close to 1.0, compute a new trial value for n using

This SIR = 1.3
Last SIR = 1.9
This n = 13
Last n = 25

The result is a trial value n of 7. Enter this value at the top of a new DPP column in the right-hand block.

Step 3: (second iteration): Compute a SIR based on PW data computed over a trial analysis period of 7 years. Again new PWs must be found for operating and maintenance costs, but other PWs do not change from step 3 (first iteration). The result is a SIR of 0.7.

Step 4: (second iteration): Again the SIR is not sufficiently close to 1.0. Compute a new trial value for n with
This SIR = 0.7
Last SIR = 1.3
This n = 7
Last n = 13
The result is a trial value n of 10. Enter this value at the top of a new column.

Step 5: (third iteration): Compute a SIR based on PW data computed over a trial analysis period of 10 years. As in the second iteration, new PWs must be found for the operating and maintenance costs. The result is 1.0; accordingly, the discounted payback period is taken as 10 years-the value of n that results in a SIR of 1.0.

Since this DPP is clearly less than 25 years, the criteria-based value of the analysis period, the ESD is considered cost effective and must be implemented.

5-5. Special studies for innovative/alternative wastewater treatment technology.

The ranking criterion for these studies is given in paragraph 2-5c. Ranking is based solely on net LCC: The net LCC of the highest-ranked innovative/alternative facility is compared to 115 percent of the net LCC of the highest-ranked conventional facility. If the former is equal to or less than the latter, the innovative/alternative facility is ranked higher and must be selected. If two or more conventional alternatives are included in the analysis, they must be ranked according to the provisions of paragraph 2-2c. If two or more innovative/alternative facilities are included, they must be ranked solely according to their LCCs: The alternative with the lowest net LCC is assigned the highest economic ranking. In the situation in which

Net LCC of alternative A (conventional) = 33.8 X 10^6 (in ABD $)

Net LCC of alternative B (conventional) = 21.2 x 10^6

Net LCC of alternative C (innovative) = 23.9 X 10^6

Net LCC of alternative D (innovative) = 30.1 x 10^6

alternative B would be ranked the higher of the conventional alternatives according to paragraph 2-2c. Alternative C would be ranked the higher of the innovative alternatives on the basis of net LCCs. Then, since

1.15 X net LCC of alternative B = 24.4 x 10^6 (in ABD $)

Net LCC of alternative C = 23.9 X 10^6

the innovative alternative C would be ranked highest and implemented.

5-6. Special intra-DOD directed economic studies.

The ranking criteria set forth in paragraph 2-2c and illustrated in paragraph 5-2 apply to these studies, unless otherwise in the directive authorizing the study effort.

CHAPTER 6

SAMPLE APPLICATIONS: THE INDIVIDUAL LCCA

6-1. Introduction.

This chapter and Appendix A provide illustrative material on how to conduct and document economic studies for MCP designs, with emphasis on the individual LCCA. Five LCCAs are presented. The five were selected in part to cover the implementation of the four sets of criteria presented in chapter 2, and in part to provide guidelines for properly applying those criteria to the three principal types of design features/elements encountered by the MCP designer-i. e., mutually exclusive energy consuming elements (such as alternative HVAC systems), mutually exclusive non-energy-consuming elements (such as alternative pavement designs), and non-mutually-exclusive "add-on" type elements (such as solar-energy systems). Analyses conducted in accordance with the criteria for general economic studies (para 2-2) are presented in paragraphs 6-2 and 6-3–the first one for a non-energy-consuming design feature, and the second for an energy-consuming one. Paragraphs 6-4 and 6-5 contain analyses conducted in accordance with the criteria for special energy-conservations studies (para 2–3 and 2–4, dealing with non-renewable resources and renewable resources, respectively). An analysis conducted in accordance with the criteria for special studies for innovative/alternative wastewater treatment technology (para 2-5) is presented in paragraph 6.

a. Cost data. All simulated case histories presented in this chapter were developed in January 1982, and all utilize cost information that generally reflects market prices and cost-growth projections of that timeframe (see para 1-4).

b. Present worth calculations. In this manual, a separate PW calculation is made (and shown) for each alternative included in the LCCA. In actual practice, however, it will occasionally be much simpler to make the PW calculations only once, for all the alternatives in the LCCA. When this approach is used, a unit cost is assumed for each of the cost types in the LCCA (e.g., initial costs, annual M&R costs, annual electricity cost, annual natural gas cost, twelfth-year replacement cost, etc.), and the PW's corresponding to these costs are calculated. For any given cost type, the actual PW for any of the alternatives is simply the product of the magnitude of that particular cost for the alternative of interest and the PW determined from the unit cost calculations. The unit-cost approach is generally used in LCCAs with a number of alternatives (three or four or more), as in the LCCAs in paragraph 6-4 and 6-6, or in the typical LCCA conducted in support of a solar-sizing design study.

c. Documentation.

(1) For LCCAs in general. The principal components of the typical LCCA documentation are:

- Cover sheet (title page)
- Contents page
- Summary of LCCA results
- Data and calculation sheets for each alternative
  - Input data summary sheets
  - PW calculation sheets
  - Backup sheets

Backup sheets, which normally comprise the bulk of the documentation, are basically of the following three types:

- Sheets copied from published documents (which may or may not be included in the official design analysis documentation for the MCP project)—for example, the Environmental Protection Agency Manual 430/9-78-009, which served as the major source of data for the wastewater treatment facility LCCA (para 6-6).
- Sheets generated for the official design analysis documentation and included therein.
- Sheets generated specifically in support of the LCCA—for example, BLAST computer-run summary sheets, showing energy con-. sumption for the HVAC alternatives studied in paragraphs 6-3 and 6-4.

Backup sheets of the third type cited above normally are included directly in the documentation for the LCCA. Backup sheets of the first two types cited above, on the other hand, normally are included in the documentation by reference only (usually on the basis input data summary sheet).

(2) For LCCAs in this manual. The documentation for the LCCAs presented in this chapter can be found in appendix A. That documentation consists, for each LCCA, of the input data summary sheet and the PW calculation sheet for each alternative, followed by the summary sheet for the LCCA as a whole. (The other principal

components of the typical LCCA documentation cited above are not presented in appendix A because of practical considerations.)

6-2. Roadway/parking surface.

This LCCA is part of the economic study for a FY 84 project, involving the construction of a reserve training building in the Tidewater area of Virginia. The building is needed to provide training facilities for a 200-member reserve unit, and is estimated to cost $3,500,000. The LCCA for the roadway/parking surface provides a simple illustration of the use of the one-step PW calculation approach in applying the general economic study criteria of paragraph 2-2 to two mutually exclusive non-energy-consuming alternatives. In addition, it serves as an example of one type of LCCA that is likely to prove to be cost-effective, in that the study results may prove to be applicable to a number of different projects in the MCP (see para 2-2a(2)).

a Input data. The basic input data summary sheets for the two alternatives (see appendix A) reflect the fact that this LCCA is conducted in accordance with the provisions for general economic studies (HQDA criteria). Thus, the discount rate is 10 percent; the ABD is the actual date on which the study is performed (the DOS); and the midpoint of construction and the BOD are taken as the actual projected dates for these events. The 25-year projected life of the roadway determines the analysis period and the analysis end date—25 years after the BOD. All costs associated with each alternative are estimated as of the DOS and listed on the input data summary sheet for that alternative, along with the actual dates on which they will be incurred (based on the actual BOD) and the sources of the cost data. The costs and the times when they are incurred are depicted graphically on a cash flow diagram. According to the criteria for general economic studies, the initial procurement/construction cost is charged at the midpoint of construction. The M&R costs for each year are accumulated as a single annual lump sum and charged at the mid-point of the year in which they are incurred the first such cost is thus charged one-half year after BOD, on 1 January 1985.

b. Computations. The PW calculations (using the -one-step approach) are shown on the PW worksheets for the two alternatives (app A).

c. Summary. The results of the LCCA are summarized on the summary worksheet (app A). The results do not appear to be clearcut-i.e., they are neither clearly conclusive nor clearly inconclusive. In spite of this, an uncertainty assessment is not required, since the relative economic ranking of the two alternatives cannot be affected by the results of the assessment (para 2-2b(9))—i.e., alternative A gets the higher ranking in any case, either by the provisions of paragraph 2-2c(1) or 2-2c(2), whichever would turn out to be appropriate (if an uncertainty assessment were made). Accordingly, the designer elected alternative A for implementation.

6-3. HVAC system: conventional design.

This LCCA is part of the economic study for a FY 84 project–the Central Administration Building at the ABCDE Ammunition Plant, located in Mississippi. The building will contain approximately 70,000 square feet, and is expected to cost approximately $70 per square foot to construct. Occupancy is projected for January 1985. The LCCA illustrates the use of the conventional PW calculation approach in applying the general-economic-study criteria for paragraph 2-2 to two mutually exclusive energy-consuming alternatives. It also illustrates the use of the artificial net salvage value (in a sense, a “retention value” or “residual value”) in those cases where the alternatives have different economic lives and the economic life of the facility (or 25 years) is not an exact multiple of those economic lives. This LCCA represents the first step in the design of an energy-consuming element of a facility, utilizing criteria and procedures no different from those used in the design of a non-energy-consuming element. At this early design stage, the designer is primarily interested in identifying the best conventional design for the application at hand, without giving any consideration to extraordinary energy-saving design initiatives. Accordingly, the LCCA is governed by the provisions of paragraph 2-2 (as was the LCCA illustrated in para 6-2). Once the best conventional design is determined (for that particular design element and for all other key elements of the building), a baseline design is established, against which the potential cost effectiveness of various extraordinary energy-saving design initiatives may be measured. Typical LCCAs for energy-conservation applications are addressed in paragraphs 6-4 and 6-5.

a. Input data. Input data are determined and entered on the data summary sheets (app A). The facility life is projected to be well in excess of 25 years; however, the analysis period is taken to extend only 25 years beyond the BOD, in accordance with the provisions of paragraph *2-2b(3)(b).* All costs associated with each alternative are estimated and listed on the data summary sheet for that alternative, along with the times they will be incurred, and the sources of cost data. The net salvage value calculated for each alternative is listed as a negative cost to be incurred on the analysis end date. All costs are shown on the cash flow diagram for each alternative.

b. Computations. The net PWs for the two alternatives are here computed by the conventional approach (for no reason other than to provide an illustration of that approach). Initial procurement costs are charged at the midpoint of construction, which here is 2.5 years after the DOS and hence after the ABD. Other one-time costs are charged at the times they are expected to be incurred. Annual costs are charged at the middle of each year; the first such cost is incurred one-half year after the BOD, which is 3.5 years after the DOS/ABD. The PW of each cost is computed, and the net LCC for each alternative is obtained as shown on the PW worksheets (app A). The annual series equivalence factors were determined from table B-2. (Linear interpolation was used to interpolate between the tabulated data points.)

c. Summary. The results of the LCCA are summarized on the summary worksheet DA Form 5605-2-R (fig. A-13). The results are clearly conclusive; alternative A is ranked higher on the he basis of its lower net LCC and is used as the baseline conventional system in the LCCA of paragraph 6-4 below.

6-4. HVAC system: energy conservation.

This LCCA, like the one presented in paragraph 6-3, is part of the economic study for the Central Administration Building at the ABCDE Ammunition Plant, in Mississippi. As indicated in paragraph 6-3, once the most economical conventional HVAC design has been determined, the next step involves the conduct of a special energy study to determine if there are any extraordinary energy-saving designs that would be more economical (than the conventional design) for this particular application. It is this second step in the HVAC system design-the special energy study required by statute–that the LCCA presented in this paragraph addresses. There are four alternatives included in the LCCA—three different energy-saving designs, all based on the use of non-renewable energy resources, plus the most economical conventional design, determined from the results of the LCCA discussed in paragraph 6-3. The LCCA illustrates the use of the conventional PW calculation approach in applying the special FEMP criteria of paragraph 2-3 to these four HVAC-system alternatives.

a. Input data. The basis input data summary sheets for the four alternatives (app A) reflect the fact that this LCCA is conducted in accordance with the provisions for special directed studies on energy conservation (FEMP criteria). Thus, the discount rate is 7 percent; a 10 percent investment credit is applied to the initial costs of all alternatives; the end-of-year convention is used for annual recurring costs; and the timing of project events is artificial. The analysis base date is taken to be 1 July 1981, corresponding to the FEMP-prescribed base data in effect at the time the study was conducted. That data is also taken as the assumed BOD and the midpoint of construction (more specifically, as the date on which initial procurement/construction costs are charged). All post-BOD one-time costs are assumed to occur on the date on which they would have occurred if the BOD were actually 1 July 1981. Thus, for example, the fan replacement for alternative A is expected to occur 15 years after BOD. This replacement would actually occur on 1 January 2000, since the actual BOD is 1 January 1985. However, for the analysis, with an artificial BOD of 1 July 1981, it is assumed that the fan replacement would occur on 1 July 1996. Moreover, as per FEMP criteria, annually recurring costs are charged at the end of each year, beginning with 1 July 1982–one year after the artificial BOD of 1 July 1981. The analysis period–25 years-is assumed to begin on the ABD (1 July 1981) and end 25 years later, on 1 July 2006. All costs associated with each alternative (including the negative net salvage costs) are listed on its input data summary and included in the calculation of its net LCC. Differential escalation rates for the cost of fuel oil and electricity are those which were prescribed for the FEMP at the time the study was conducted, as indicated in paragraph 1-4. In accordance with HQDA (DAEN-ECE-G) guidance at the time of the study, these rates were determined from tabulated values for the Commercial Sector, published in 10 CFR 436A. The rates used are those for DOE Region 4, the appropriate region for a facility in Mississippi (app C). With regard to cost estimates, the preferred approach is to have all costs reflect market prices as of the ABD. If these costs are too difficult for the designer to obtain, the designer is permitted-as an approximation—to base all costs on the purchasing power of the dollar on the DOS, and to assume that this represents the purchasing power of the dollar on the ABD. In any case, when the designer elects to use this approximation, he or she must do so for *all costs.*

b. Computations. The present worths of the four alternatives are computed by the conventional approach and entered on PW worksheets (app A). This approach is used here to provide additional examples of its use, this time following the provision of paragraph 2-3 (FEMP criteria); the one-step approach would have given the same results. A 10 percent credit is applied to the initial investment cost of all alternatives. The effect of this credit is to reduce the extra initial investment cost of the energy-saving alternatives. The annual series equivalence factors were determined on the basis of linear interpolation between tabulated data points in table B-2. Note that the PW of conventional alternative A is recalculated here according to the FEMP criteria of paragraph 2-3; the resulting net LCC differs from that calculated in paragraph 6–3 using paragraph 2-2 criteria.

c. Summary. The results of the PW calculations are summarized on the LCCA summary sheet DA Form 5605-2-R (fig A-13). The four alternatives are ranked solely on the basis of net LCC—the alternative with the lowest net LCC receiving the highest economic ranking. The difference in net LCC between the highest-ranked alternative (alternative D) and the second highest-ranked alternative (alternative B) is about 1 percent, must less than the probable accuracy of the cost data involved in the analysis. Thus, these alternatives tie considered to be tied, and the designer must use his or her best judgment to select either alternative D or alternative B for implementation (para 2-3c). In this case, the designer selected alternative D because it is expected to consume less energy than alternative B.

6-5. Domestic water heating system: energy conservation (solar).

This LCCA, like those presented in paragraphs 6-3 and 6-4, is part of the economic study for the Central Administration Building at the ABCDE Ammunition Plant in Mississippi. Like the LCCA presented in paragraph 6-4, it is conducted as part of the special energy study for the project, to determine if there are any extraordinary energy-saving designs that would be more economical (than the best conventional design) for this particular application. Unlike that LCCA, however, the LCCA presented here deals with the domestic hot water (DHW) system, and the use of non-renewable energy resources—in the form of solar-energy-is specifically considered. Accordingly, this LCCA is considered to be responsive to the special statutory requirement on energy conservation for MCP facilities (as described in paragraph 2-4). It illustrates the use of the conventional PW calculation approach: for a design application in which the alternatives are not necessarily mutually exclusive (i.e., the solar-energy system cannot stand alone, but must have a conventional system as backup), and in applying the special FEMP criteria of paragraph 2-4 for the case of an incremental approach, where only incremental costs (i.e., cost differences) between two alternatives are considered. It also illustrates the special economic ranking calculations—savings-to-investment ratio and discounted payback period (SIR and DPP)–which may be required for certain types of energy-conservation applications (e.g., solar-energy systems).

a. Input data. The baseline alternative (alternative A) is the best conventional design-an electric DHW system (as determined from the results of an LCCA conducted earlier and not illustrated herein). The other alternative (alternative B) is a DHW system that consists of a solar-energy-based heating system and a conventional heating system for backup. The conventional system selected for backup is the alternative A electric heating system. In accordance with standard practice for the incremental-analysis approach, only the incremental costs—i.e., the cost differences between the alternative B combined system and the alternative A baseline system—are considered, and only these are listed on the single basic input data summary worksheet (app A). These are the extra costs (and/or cost savings) that are attributable to the solar-energy “add-on”. (The cost figures for each of the two alternatives considered in the typical incremental-analysis approach, from which the incremental costs are calculated, would be provided on the appropriate backup sheets in the LCCA documentation.) The basic input data summary worksheet reflects the fact that this LCCA is conducted in accordance with the provisions for special directed studies for energy conservation (FEMP), as was the LCCA presented in paragraph 6-4. The extensive discussion provided there on the application of the FEMP criteria—e.g., the use of a 7 percent discount rate, 10 percent investment credit, end-of-year convention for annually recurring costs, artificial timing for project events, 1 July 1981 ABD, differential escalation rates from 1982 CFR, etc. —is applicable to this LCCA as well. An analysis period of 25 years is used here, based on the assumption that the economic life of the facility will be at least 25 years. It is also assumed: that the economic lives of both the solar-energy system and the electric heating system are 25 years, and that the present worth (PW) of any net salvage value that would properly be claimed would be small enough to ignore. (It should be noted that, while both of these assumptions may be common, other views are equally common. The economic life of a typical solar-energy system is considered by many to be more on the order of 15-20 years, than 25 years, and the PW of the net salvage value of a typical solar-energy system is considered by many to be too large to ignore-i. e., based on the not uncommon assumption of a net salvage value for the solar "add-on", of as much as 20 percent or more of the initial investment cost, for the scrap value of copper tubing and other materials.) The incremental initial investment cost shown includes the additional cost of design for the solar-energy "add-on" as well as the additional cost of supervision and administration (S&A) anticipated, both considered to be relevant and significant in an application such as this (i.e., one involving an "add-on"). Contingency costs are not included, however, in accordance with standard practice.

b. Computations. The net LCC savings attributable to the solar-energy "add-on" to the conventional DHW system is computed directly by the conventional PW approach applied to the incremental costs of alternative B vs. alternative A (app A). A 10 percent investment credit is applied to the incremental initial investment cost, as required. The annual series equivalence factors are determined from table B-2, with linear interpolation used for the factor for electricity costs. As required by the Congress, the SIR and DPP are also computed (app A). (Note that the worksheet for the SIR and DPP calculations has been designed to be used with either the incremental approach or the tradeoff approach.)

c. Summary. The net LCC savings, SIR, and DPP are reported on the summary sheet DA Form 5605-2-R (Fig A-13). Since the net LCC savings is positive, the solar/electric water heating system must be selected for implementation. (Note that the SIR of 1.5 and the DPP of 13 years also indicate that the solar/electric system is cost effective.)

6-6. Wastewater-treatment facility.

This LCCA–conducted during the early stages of design of a wastewater-treatment facility for Fort Oaks, Alabama-is considered to be responsive to the statutory requirement that all new Federal wastewater treatment facilities make use of innovative or alternative processes and techniques whenever it is not economically prohibitive to do so (i.e., as long as the additional cost of doing so is no more than 15 percent, on an LCC basis). There are four alternatives included in the LCCA, two of which are considered to represent conventional plants (alternatives A and D) and two of which are considered to qualify as innovative/alternative concepts (alternatives B and C). (The alternatives considered–and the basic input cost data—are based largely 'on the guidance provided by the Environmental Protection Agency in EPA Manual 430/9 -78-009.) This LCCA illustrates once again the use of the conventional PW calculation approach. It also illustrates the proper implementation of the special economic ranking criteria of paragraph 2-5 and the proper approach to use when the economic life of the facility is expected to be substantially in excess of 25 years.

a. Input data. The basis input data summary sheets for the four alternatives (app A) reflect the fact that this LCCA, like those described in paragraphs 2-2 and 2-3, is conducted in accordance with the provisions for general economic studies (HQDA criteria). Thus, the discount rate is 10 percent; the mid-year convention is used for annually recurring costs; the timing of all events is natural-i. e., as actually projected; etc. Although the economic lives of the alternatives considered are projected to be well in excess of 25 years-actually, on the order of 40-50 years (on the basis of the best information available at the time the study was conducted) the analysis period is taken to extend only 25 years beyond the BOD, in accordance with the provisions of paragraph 2-2b(3)(b). All costs associated with each of the alternatives are estimated (in large part, as indicated above, based on guidance contained in EPA Manual 430/9-78-009), and then listed on the data summary sheet for that alternative, along with the times they will be incurred, and the sources of cost data, and plotted on the cash flow diagram for that alternative (app A). All relevant and significant costs are provided for, including land acquisition costs, where appropriate (i.e., where land available at the site is inadequate to accommodate the particular alternative, as in the case for alternative D). It should be noted that a methane-gas collection system is incorporated into the design of alternatives A, B, and C, and that this fact is appropriately reflected both in the initial investment costs for these alternatives ($20,000 extra, in each case) and in the annual cost of electricity (reduced by the savings effected through the use of the methane).

b. Computations. The present worths of the various alternatives are computed by the conventional approach, and are entered on the PW worksheets (app A). The annual series equivalence factors were determined on the basis of linear interpolation between tabulated data points in table B-2.

c. *Summary.* The results of the LCCA are summarized on the summary worksheet DA Form 5605.2-R (Fig A-13). Paragraph 2-5c requires that the conventional alternatives be ranked separately, in accordance with the criteria of paragraph 2-2c; that the innovative alternatives be ranked separately, on the basis of their LCCs; and finally that the net LCC of the highest ranked innovative alternative be compared with 115 percent of the net LCC of the highest ranked conventional alternative to determine which of the two will be selected for implementation. Based on these ranking criteria, alternative A is given the higher ranking of the conventional alternatives, and alternative B is given the higher ranking of the innovative alternatives. Since the net LCC of innovative alternative B exceeds 115 percent of the net LCC of conventional alternative A, alternative A is ranked higher and selected for implementation. Note that the unavailability of a substantial amount of extra land at this particular installation at or near the site of the facility has a significant effect on the economic ranking of the alternatives. At another installation, where extra land at the site of interest might be plentiful and readily available, the relative rankings of these same alternatives in all likelihood would be different.

APPENDIX A

LIFE CYCLE COST ANALYSIS EXAMPLES

LIST OF EXAMPLES	PAGE

ROADWAY/PARKING SURFACE

Project No. & Title PN 063 (FY84) Reserve Bldg.
Installation & Location Reserve Center, Virginia
Design Feature Roadway / Parking Surface
Alt. No. A Title Asphalt w/ 2" Wearing Surface

LIFE CYCLE COST ANALYSIS
BASIC INPUT DATA SUMMARY

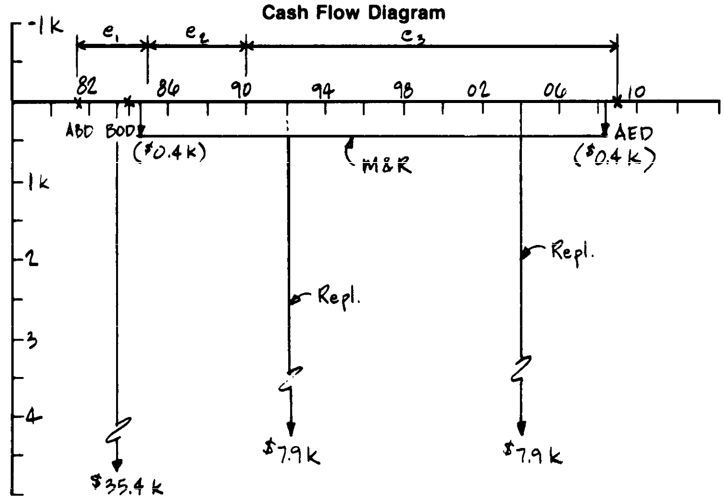
For use of this form, see TM 5-802-1; the proponent agency is USACE.

Criteria Reference		HQDA
Date of Study (DOS)		1 Jan 82
Analysis Base Date (ABD)		1 Jan 82
Analysis End Date (AED)		1 Jul 09
Midpoint of Construction		1 Jan 84
Beneficial Occupancy Date (BOD)	Actual Projected	1 Jul 84
	Assumed for Analysis	1 Jul 84
DOE Region		3
Annual Discount Rate		10%

Type of Cost	Differential Escalation Rate per Year (%)		
	Timeframe: Jul - Jun		
	82-85	85-90	90-09
All	0.00	0.00	0.00

Principal Assumptions

Cash Flow Diagram



Note: Time lines denote 1 Jul of year shown.

Cost Element	Cost on ABD ☒ $ x 10³ ☐ $ x 10⁶	Time Cost Incurred** Actual Projected Dates	Time Cost Incurred** Dates for Analysis (If Different)*	Source(s) of Data
Initial Investment Cost	35.4	1 Jan 84		Engineer's Project Estimate
Replacement (1"top.) yr 8	7.9	1 Jul 92		Eng. Est. - Backup Sheet
Replacement (1"top) yr 16	7.9	1 Jul 00		Eng. Est. - Backup Sheet
M&R	0.4	1 Jan85 - 1 Jan 09		Eng. Est. - Backup Sheet

DA FORM 5605-3-R, DEC 86

*When 10 CFR436A Criteria Apply
**For Recurring Annual Costs, show date of first and last costs only.

Sheet ______ of ______

Project No. & Title PN 063(FY84) Reserve Bldg.
Installation & Location Reserve Center, Virginia
Design Feature Roadway / Parking Surface
Alt. No. A Title Asphalt w/ 2" Wearing Surface

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: ONE-STEP APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

One-Time Costs ☒ $ x 10^3 ☐ $ x 10^6	Years from ABD	Cost On ABD	One Step Adj.Factor Table 1	Present Worth on ABD
Initial Investment Cost	2.0	35.4	0.8264	29.3
Replacement (1" top.) yr. 8	10.5	7.9	0.3676	2.9
Replacement (1" top.) yr. 16	18.5	7.9	0.1715	1.4

Criteria Reference	HQDA
Analysis Base Date (ABD)	1 Jan 82
Analysis End Date (AED)	1 Jul 09
Midpoint of Construction	1 Jan 84
BOD for Analysis	1 Jul 84
Annual Discount Rate	10%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: Jul-Jun 82-85	85-90	90-09
All	0.00	0.00	0.00

Annual Costs ☒ $ x 10^3 ☐ $ x 10^6	Total No. of Payments	Annual Cost on ABD	Total Nominal Cost on ABD	One Step Adjustment Factor* Table Factor x DOS Correction	Present Worth on ABD
M&R	25	0.4	10.0	0.2861 × $(1.008)^6$	3.0

	Initial Costs	Energy/Fuel Costs	M&R Costs	Other Costs	Total
Net Present Worth:	29.3 +	0.0 +	3.0 +	4.3 =	36.6

DA FORM 5605-5-R, DEC 86

*Use One-Step Table 2 for M&R costs (e = 0).
Use One-Step Table 3 for energy/fuel costs (e prescribed e value).

Sheet ______ of ______

Project No. & Title PN 063 (FY84) Reserve Bldg.
Installation & Location Reserve Center, Virginia
Design Feature Roadway / Parking Surface
Alt. No. B Title Asphalt w/ 3" Wearing Surface

LIFE CYCLE COST ANALYSIS
BASIC INPUT DATA SUMMARY

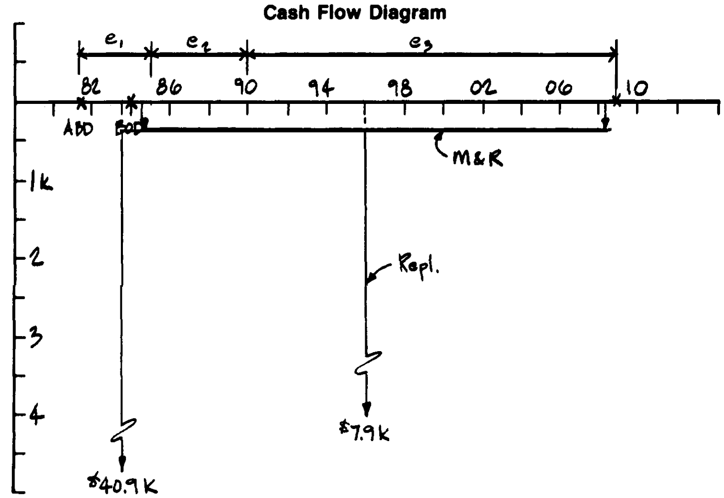
For use of this form, see TM 5-802-1; the proponent agency is USACE.

Criteria Reference		HQDA
Date of Study (DOS)		1 Jan 82
Analysis Base Date (ABD)		1 Jan 82
Analysis End Date (AED)		1 Jul 09
Midpoint of Construction		1 Jan 84
Beneficial Occupancy Date (BOD)	Actual Projected	1 Jul 84
	Assumed for Analysis	1 Jul 84
DOE Region		3
Annual Discount Rate		10%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: Jul - Jun		
	82-85	85-90	90-09
All	0.00	0.00	0.00

Principal Assumptions

Cash Flow Diagram



Note: Time lines denote 1 Jul of year shown

Cost Element	Cost on ABD ☒ $ x 10³ ☐ $ x 10⁶	Time Cost Incurred** Actual Projected Dates	Dates for Analysis (If Different)*	Source(s) of Data
Initial Investment Cost	40.9	1 Jan 84		Engineer's Project Estimate
Replacement (1" top.) yr. 12	7.9	1 Jul 96		Eng. Est. — Backup Sheet
M&R	0.3	1 Jan 85 - 1 Jan 09		Eng. Est. — Backup Sheet

DA FORM 5605-3-R, DEC 86

*When 10 CFR436A Criteria Apply
**For Recurring Annual Costs, show date of first and last costs only.

Sheet______ of______

Project No. & Title PN 063 (FY84) Reserve Bldg.
Installation & Location Reserve Center, Virginia
Design Feature Roadway / Parking Surface
Alt. No. B Title Asphalt w/ 3" Wearing Surface

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: ONE-STEP APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

One-Time Costs ☒ $ x 10³ ☐ $ x 10⁶	Years from ABD	Cost On ABD	One Step Adj.Factor Table 1	Present Worth on ABD
Initial Investment Cost	2.0	40.9	0.8264	33.8
Replacement (1" top.) yr. 12	14.5	7.9	0.2511	2.0

Criteria Reference	HQDA
Analysis Base Date (ABD)	1 Jan 82
Analysis End Date (AED)	1 Jul 09
Midpoint of Construction	1 Jan 84
BOD for Analysis	1 Jul 84
Annual Discount Rate	10%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: Jul - Jun 82-85	85-90	90-09
All	0.00	0.00	0.00

Annual Costs ☒ $ x 10³ ☐ $ x 10⁶	Total No. of Payments	Annual Cost on ABD	Total Nominal Cost on ABD	One Step Adjustment Factor* Table Factor x DOS Correction	Present Worth on ABD
M&R	25	0.3	7.5	$0.2861 \times (1.008)^6$	2.3

	Initial Costs		Energy/Fuel Costs		M&R Costs		Other Costs		Total
Net Present Worth:	33.8	+	0.0	+	2.3	+	2.0	=	38.1

DA FORM 5605-5-R, DEC 86

*Use One-Step Table 2 for M&R costs (e = 0).
Use One-Step Table 3 for energy/fuel costs (e = prescribed e value).

Sheet ____ of ____

Project No. & Title PN 063 (FY84) Reserve Bldg.
Installation & Location Reserve Center, Virginia
Design Feature Roadway / Parking Surface

Date of Study 1 Jan 82

LIFE CYCLE COST ANALYSIS SUMMARY

For use of this form, see TM 5-802-1; the proponent agency is USACE.

ALTERNATIVES ANALYZED						
No.	Description/Title	Present Worth ☒ $ x 10³ ☐ $ x 10⁶				
		Initial	Energy	M&R	Other	Total
A	Asphalt w/ 2" Wearing Surface	29.3	0.0	3.0	4.3	36.6
B	Asphalt w/ 3" Wearing Surface	33.8	0.0	2.3	2.0	38.1

ECONOMIC RANKING				
Rank	Alternative No. & Title	Economic Advantages of Top-Ranked Alternative: LCC (PW) Difference (Dollars & Percent)	Other (Initial, Energy, Etc.)	Basis for No. 1 Ranking
1	A Asphalt w/ 2" Wearing Surface	$1,500, 4%	Lower initial cost	Lower LCC (Uncertainty Not Relevant)
2	B Asphalt w/ 3" Wearing Surface			

KEY ASSUMPTIONS	NARRATIVE SUMMARY (Comments/Lessons Learned/Observations/Recommendations/Etc.)
	This LCCA is somewhat project independent and should therefore be used for comparison purposes with future roadway / parking surface LCCA's.

Key Participants - Name	Discipline	Organization	Telephone No.
Kenneth Anderson, PE	Civil	Blank Associates	(202) 555-0000

DA FORM 5605-2-R, DEC 86

Sheet ______ of ______

HVAC SYSTEM: CONVENTIONAL DESIGN

Project No. & Title PN 175 (FY84) Admin. Bldg.
Installation & Location ABCDE Ammo. Plant, Miss.
Design Feature HVAC System - Conventional
Alt. No. A Title Const. Vol. w/ Recip. Chiller

LIFE CYCLE COST ANALYSIS
BASIC INPUT DATA SUMMARY

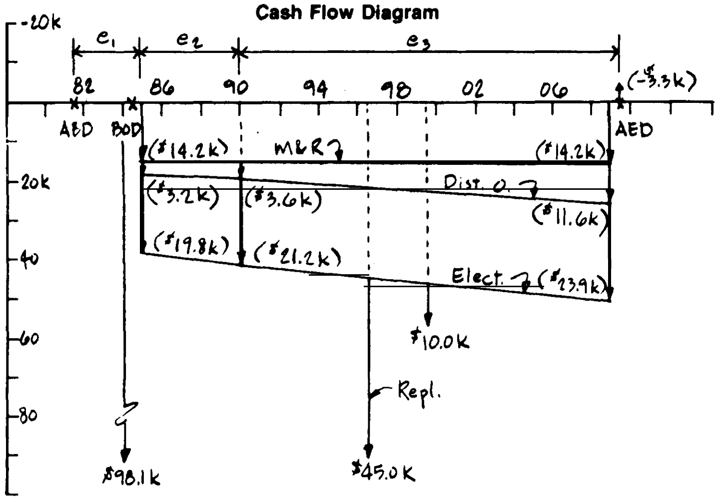
For use of this form, see TM 5-802-1; the proponent agency is USACE.

Criteria Reference		HQDA
Date of Study (DOS)		1 Jan 82
Analysis Base Date (ABD)		1 Jan 82
Analysis End Date (AED)		1 Jan 10
Midpoint of Construction		1 Jul 84
Beneficial Occupancy Date (BOD)	Actual Projected	1 Jan 85
	Assumed for Analysis	1 Jan 85
DOE Region		4
Annual Discount Rate		10%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: Jul - Jun		
	82-85	85-90	90-10
Elect.	5.28	1.41	0.63
Dist. O.	2.52	2.64	6.35
Other	0.00	0.00	0.00

Principal Assumptions

Cash Flow Diagram



Note: Time lines denote 1 Jul of year shown

Cost Element	Cost on ABD [X] $ x 10³ [ ] $ x 10⁶	Time Cost Incurred** Actual Projected Dates	Time Cost Incurred** Dates for Analysis (If Different)*	Source(s) of Data
Initial Investment Cost	98.1	1 Jul 84		Engineer's Project Estimate
Replacement (Plant) yr. 12	45.0	1 Jan 97		Eng. Est. - Backup Sheet
Replacement (Fan) yr. 15	10.0	1 Jan 00		Eng. Est. - Backup Sheet
Salvage yr. 25	-3.3	1 Jan 10		Eng. Est. - Backup Sheet
Elect.	16.5	1 Jul 85 - 1 Jul 09		BLAST Program Estimate
Dist. O.	2.9	1 Jul 85 - 1 Jul 09		BLAST Program Estimate
M&R	14.2	1 Jul 85 - 1 Jul 09		Eng Est. - Backup Sheet

DA FORM 5605-3-R, DEC 86

*When 10 CFR436A Criteria Apply
**For Recurring Annual Costs, show date of first and last costs only.

Sheet ______ of ______

Project No. & Title PN 175(FY84) Admin. Bldg.
Installation & Location ABCDE Ammo. Plant, Miss.
Design Feature HVAC System – Conventional
Alt. No. A Title Const. Vol. w/ Recip. Chiller

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: CONVENTIONAL APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

One-Time Costs ☒ $ x 10³ ☐ $ x 10⁶	Years From ABD	Cost on ABD	Escalation Factor	Escal. Cost (Time Incurred)	Discount Factor	Present Worth on ABD
Initial Investment Cost	2.5	98.1	$(1.0)^{2.5}$	98.1	$(\frac{1}{1.1})^{2.5}=0.788$	77.3
Replacement (Plant) ... 12	15.0	45.0	$(1.0)^{15}$	45.0	$(\frac{1}{1.1})^{15}=0.239$	10.8
Replacement (Fan) ... 15	18.0	10.0	$(1.0)^{18}$	10.0	$(\frac{1}{1.1})^{18}=0.180$	1.8
Salvage 25	28.0	3.3	$(1.0)^{28}$	3.3	$(\frac{1}{1.1})^{28}=0.069$	0.2

Criteria Reference	HQDA
Analysis Base Date (ABD)	1 Jan 82
Analysis End Date (AED)	1 Jan 10
Midpoint of Construction	1 Jul 84
BOD for Analysis	1 Jan 85
Annual Discount Rate	10%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: Jul–Jun 82-85	85-90	90-10
Elect.	5.28	1.41	0.63
Dist. O.	2.52	2.64	6.35
Other	0.00	0.00	0.00

Annual Costs ☒ $ x 10³ ☐ $ x 10⁶	Years from ABD: First Incurred	Last Incurred	Total No. of Payments	Annual Cost on ABD	Escalation Factor	Escal. Cost (Time First Incurred): 1st Ann. Cost in Series	Annual Series Eq Factor	Equiv. Single Cost	Discount Factor	Present Worth on ABD
Elect. ① 85-89	3.5	7.5	5	16.5	$(1.0528)^{3.5}$	19.8	4.278	84.7	$(\frac{1}{1.1})^{3.5}=0.7164$	60.7
② 90-09	8.5	27.5	20	16.5	$(1.0528)^{3.5}(1.0141)^{5}$	21.2	9.768	207.0	$(\frac{1}{1.1})^{8.5}=0.4448$	92.1
Dist. O. ① 85-89	3.5	7.5	5	2.9	$(1.0252)^{3.5}$	3.2	4.375	14.0	0.7164	10.0
② 90-09	8.5	27.5	20	2.9	$(1.0252)^{3.5}(1.0264)^{5}$	3.6	14.805	53.3	0.4448	23.7
M&R	3.5	27.5	25	14.2	$(1.0)^{3.5}$	14.2	9.985	141.8	0.7164	101.6

	Initial Costs	Energy/Fuel Costs	M&R Costs	Other Costs	Total
Net Present Worth	77	187	102	12	378

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Sheet ____ of ____

Project No. & Title PN 175 (FY84) Admin. Bldg.
Installation & Location ABCDE Ammo. Plant, Miss.
Design Feature HVAC System - Conventional
Alt. No. B Title Variable Air Vol w/ R. Chiller

LIFE CYCLE COST ANALYSIS
BASIC INPUT DATA SUMMARY

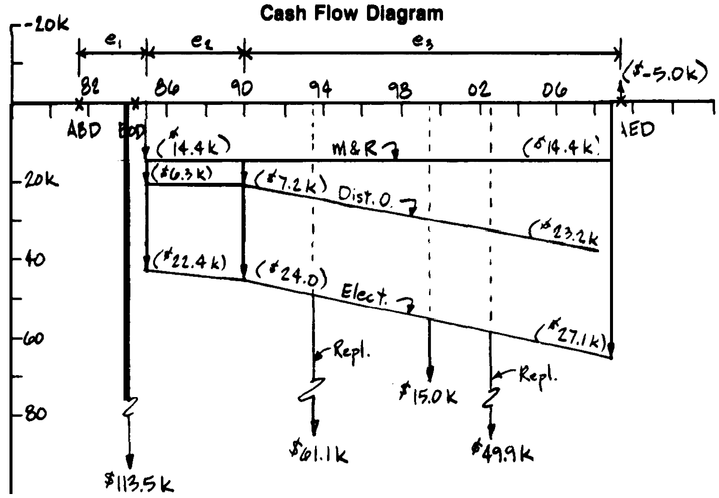
For use of this form, see TM 5-802-1; the proponent agency is USACE.

Criteria Reference		HQDA
Date of Study (DOS)		1 Jan 82
Analysis Base Date (ABD)		1 Jan 82
Analysis End Date (AED)		1 Jan 10
Midpoint of Construction		1 Jul 84
Beneficial Occupancy Date (BOD)	Actual Projected	1 Jan 85
	Assumed for Analysis	1 Jan 85
DOE Region		4
Annual Discount Rate		10%

Type of Cost	Differential Escalation Rate per Year (%)		
	Timeframe: Jul - Jun		
	82-85	85-90	90-10
Elect.	5.28	1.41	0.63
Dist. O.	2.52	2.64	6.35
Other	0.00	0.00	0.00

Principal Assumptions

Cash Flow Diagram



Note: Time lines denote 1 Jul of year shown

Cost Element	Cost on ABD ☒ $ x 10³ ☐ $ x 10⁶	Time Cost Incurred** Actual Projected Dates	Time Cost Incurred** Dates for Analysis (If Different)*	Source(s) of Data
Initial Investment Cost	113.5	1 Jul 84		Engineer's Project Estimate
Replacement (Plant) yr. 9	61.1	1 Jan 94		Eng. Est. - Backup Sheet
Replacement (Fan) yr. 15	15.0	1 Jan 00		Eng. Est. - Backup Sheet
Replacement (Plant) yr 18	48.9	1 Jan 03		Eng. Est. - Backup Sheet
Salvage	- 5.0	1 Jan 10		Eng. Est. - Backup Sheet
Elect.	18.7	1 Jul 85 - 1 Jul 09		BLAST Program Estimate
Dist. O.	5.8	1 Jul 85 - 1 Jul 09		BLAST Program Estimate
M & R	14.4	1 Jul 85 - 1 Jul 09		Eng. Est. - Backup Sheet

DA FORM 5605-3-R, DEC 86

*When 10 CFR436A Criteria Apply
**For Recurring Annual Costs, show date of first and last costs only.

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Project No. & Title PN 175 (FY84) Admin. Bldg.
Installation & Location ABCDE Ammo. Plant, Miss.
Design Feature HVAC System – Conventional
Alt. No. B Title Variable Air Vol. w/ R. Chiller

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: CONVENTIONAL APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

One-Time Costs ☒ \$ x 10³ ☐ \$ x 10⁶	Years From ABD	Cost on ABD	Escalation Factor	Escal. Cost (Time Incurred)	Discount Factor	Present Worth on ABD
Initial Investment Cost	2.5	113.5	$(1.0)^{2.5}$	113.5	$\left(\frac{1}{1.1}\right)^{2.5}=0.778$	88.3
Replacement (Plant) yr. 9	12.0	61.1	$(1.0)^{12}$	61.1	$\left(\frac{1}{1.1}\right)^{12}=0.319$	19.5
Replacement (Fan) yr. 15	18.0	15.0	$(1.0)^{15}$	15.0	$\left(\frac{1}{1.1}\right)^{18}=0.180$	2.7
Replacement (Plant) yr. 18	21.0	48.9	$(1.0)^{21}$	48.9	$\left(\frac{1}{1.1}\right)^{21}=0.135$	6.6
Salvage yr. 25	28.0	-5.0	$(1.0)^{28}$	-5.0	$\left(\frac{1}{1.1}\right)^{28}=0.069$	-0.3

Criteria Reference	HQDA
Analysis Base Date (ABD)	1 Jan 82
Analysis End Date (AED)	1 Jan 10
Midpoint of Construction	1 Jul 84
BOD for Analysis	1 Jan 85
Annual Discount Rate	10%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: Jul – Jun 82-85	85-90	90-10
Elect.	5.28	1.41	0.63
Dist. O.	2.52	2.64	6.35
Other	0.00	0.00	0.00

Annual Costs ☒ \$ x 10³ ☐ \$ x 10⁶	Years from ABD: First Incurred	Last Incurred	Total No. of Payments	Annual Cost on ABD	Escalation Factor	Escal. Cost (Time First Incurred): 1st Ann. Cost in Series	Annual Series Eq Factor	Equiv. Single Cost	Discount Factor	Present Worth on ABD
Elect. ① 85-89	3.5	7.5	5	18.7	$(1.0528)^{3.5}$	22.4	4.278	95.8	$\left(\frac{1}{1.1}\right)^{3.5}=0.7164$	68.6
② 90-09	8.5	27.5	20	18.7	$(1.0528)^{3.5}(1.0141)^{5}$	24.0	9.768	234.4	$\left(\frac{1}{1.1}\right)^{8.5}=0.4448$	104.3
Dist. O. ① 85-89	3.5	7.5	5	5.8	$(1.0252)^{3.5}$	6.3	4.375	27.6	0.7164	19.8
② 90-09	8.5	27.5	20	5.8	$(1.0252)^{3.5}(1.0264)^{5}$	7.2	14.805	106.6	0.4448	47.4
M&R	3.5	27.5	25	14.4	$(1.0)^{3.5}$	14.4	9.985	143.8	0.7164	103.0

	Initial Costs		Energy/Fuel Costs		M&R Costs		Other Costs		Total
Net Present Worth:	88	+	240	+	103	+	28	=	459

DA FORM 5605-4-R, DEC 86

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Project No. & Title PN 175 (FY84) Admin. Bldg.
Installation & Location ABCDE Ammo. Plant, Miss.
Design Feature HVAC System - Conventional

Date of Study 1 Jan 82

LIFE CYCLE COST ANALYSIS SUMMARY

For use of this form, see TM 5-802-1; the proponent agency is USACE.

ALTERNATIVES ANALYZED						
No.	Description/Title	Present Worth ☒ $ x 10³ ☐ $ x 10⁶				
		Initial	Energy	M&R	Other	Total
A	Const. Vol. w/ Recip. Chiller	77	187	102	12	378
B	Variable Air Vol. w/ R. Chiller	88	240	103	28	459

ECONOMIC RANKING				
Rank	Alternative No. & Title	Economic Advantages of Top-Ranked Alternative		Basis for No. 1 Ranking
		LCC (PW) Difference (Dollars & Percent)	Other (initial, Energy, Etc.)	
1 2	A Const. Vol w/ Recip. Chiller B Variable Air Vol w/ R. Chiller	$81,000, 21%	Lower initial cost, Less energy consumption	Lower LCC

KEY ASSUMPTIONS	NARRATIVE SUMMARY (Comments/Lessons Learned/Observations/Recommendations/Etc.)

Key Participants - Name	Discipline	Organization	Telephone No.
William Smith, PE (Major USA, Ret.)	Mechanical	A-E Associates	(601) 555-3000
Rosevelt Brown, PE	Electrical	A-E Associates	(601) 555-3000

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Sheet ______ of ______

HVAC SYSTEM: ENERGY CONSERVATION

Project No. & Title PN 175 (FY 84) Admin. Bldg.

Installation & Location ABCDE Ammo. Plant, Miss.

Design Feature HVAC System: Energy Conservation

Alt. No. A Title Const. Vol. w/ Recip. Chiller (no setback, no economy cycle)

LIFE CYCLE COST ANALYSIS

BASIC INPUT DATA SUMMARY

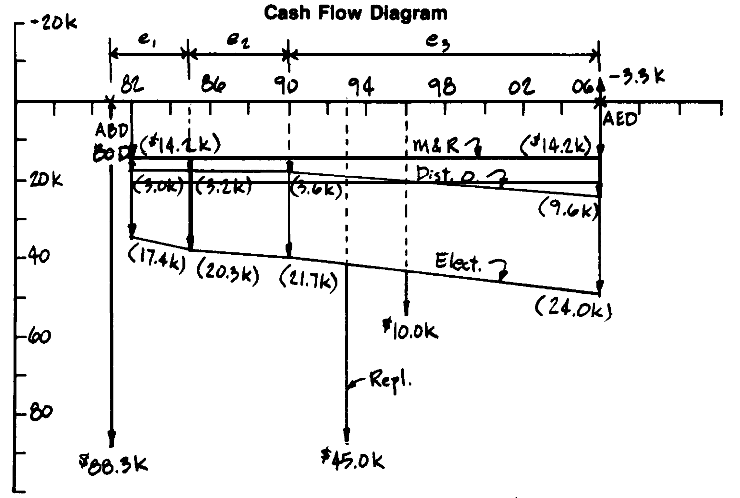
For use of this form, see TM 5-802-1; the proponent agency is USACE.

Criteria Reference		FEMP
Date of Study (DOS)		1 Jan 82
Analysis Base Date (ABD)		1 Jul 81
Analysis End Date (AED)		1 Jul 06
Midpoint of Construction		N.A.
Beneficial Occupancy Date (BOD)	Actual Projected	1 Jan 85
	Assumed for Analysis	1 Jul 81
DOE Region		4
Annual Discount Rate		7%

Type of Cost	Differential Escalation Rate per Year (%)		
	Timeframe: Jul - Jun		
	81-85	85-90	90-06
Elect.	5.28	1.41	0.63
Dist. O.	2.52	2.64	6.35
Other	0.00	0.00	0.00

Principal Assumptions

Cash Flow Diagram



Note: Time lines denote 1 Jul of year shown

Cost Element	Cost on ABD ☒ \$ x 10³ ☐ \$ x 10⁶	Time Cost Incurred** Actual Projected Dates	Time Cost Incurred** Dates for Analysis (If Different)*	Source(s) of Data
Initial Investment Cost	88.3 (98.1 less 10%)	1 Jul 84	1 Jul 81	Engineer's Project Estimate
Replacement (Plant) yr 12	45.0	1 Jan 97	1 Jul 93	Eng. Est. - Backup Sheet
Replacement (Fan) yr 15	10.0	1 Jan 00	1 Jul 96	Eng. Est. - Backup Sheet
Salvage yr 25	-3.3	1 Jan 10	1 Jul 06	Eng. Est. - Backup Sheet
Elect.	16.5	1 Jul 85 - 1 Jul 09	1 Jul 82 - 1 Jul 06	BLAST Program Estimate
Dist. O.	2.9	1 Jul 85 - 1 Jul 09	1 Jul 82 - 1 Jul 06	BLAST Program Estimate
M&R	14.2	1 Jul 85 - 1 Jul 09	1 Jul 82 - 1 Jul 06	Eng. Est. - Backup Sheet

DA FORM 5605-3-R, DEC 86

*When 10 CFR436A Criteria Apply

**For Recurring Annual Costs, show date of first and last costs only.

Sheet ______ of ______

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Installation & Location ABCDE Ammo. Plant, Miss.

Design Feature HVAC System: Energy Conservation

Alt. No. A Title Const. Vol. w/ Recip. Chiller (no setback, no economy cycle)

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: CONVENTIONAL APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

Crit..ria Reference	FEMP
Analysis Base Date (ABD)	1 Jul 81
Analysis End Date (AED)	1 Jul 06
Midpoint of Construction	N.A.
BOD for Analysis	1 Jul 81
Annual Discount Rate	7%

Type of Cost	Differential Escalation Rate per Year (%)		
	Timeframe: Jul-Jun 81-85	85-90	90-06
Elect.	5.28	1.41	0.63
Dist. O.	2.52	2.64	6.35
Other	0.00	0.00	0.00

One-Time Costs ☒ $ x 10³ ☐ $ x 10⁶	Years From ABD	Cost on ABD	Escalation Factor	Esca. Cost (Time Incurred)	Discount Factor	Prese... Worth on ABD
Net Investment Cost	0	88.3	$(1.0)^0$	88.3	$(\frac{1}{1.07})=1.0$	88.3
Replacement (Plant) yr. 12	12	45.0	$(1.0)^{12}$	45.0	$(\frac{1}{1.07})^{12}=0.444$	20.0
Replacement (Fan) yr. 15	15	10.0	$(1.0)^{15}$	10.0	$(\frac{1}{1.07})^{15}=0.362$	3.6
Salvage yr. 25	25	-3.3	$(1.0)^{25}$	-3.3	$(\frac{1}{1.07})^{25}=0.184$	-0.6

Annual Costs ☒ $ x 10³ ☐ $ x 10⁶	Years from ABD: First Incurred	Last Incurred	Total No. of Payments	Annual Cost on ABD	Escalation Factor	Escal. Cost (Time First Incurred): 1st Ann. Cost in Series	Annual Series Eq Factor	Equiv. Single Cost	Discount Factor	Present Worth on ABD
Elect. ① 82-84	1.0	3.0	3	16.5	$(1.0528)^1$	11.4	2.752	51.4	0.9346	48.0
② 85-89	4.0	8.0	5	16.5	$(1.0528)^4$	20.3	4.504	91.4	0.7629	69.7
③ 90-06	[illegible]	[illegible]	17	16.5	$(1.0528)^4(1.0141)^5$	21.7	10.888	236.3	0.5439	128.5
D.O. ① 82-84	[illegible]	[illegible]	[illegible]	[illegible]	$(1.0252)^1$	3.0	2.876	8.6	0.9346	8.0
② 85-89	4.0	8.0	5	2.9	$(1.0252)^4$	3.2	4.609	14.7	0.7629	11.2
③ 90-06	[illegible]	[illegible]	17	2.9	$(1.0252)^4(1.0264)^5$	3.6	16.211	58.4	0.5439	31.8
M&R	1.0	25.0	25	14.2	$(1.0)^1$	14.2	12.469	177.1	0.9346	165.5

	Initial Costs	Energy Costs	M&R Costs	Other Costs	
Net Present Worth	88	197	166	23	574

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LIFE CYCLE COST ANALYSIS
BASIC INPUT DATA SUMMARY

For use of this form, see TM 5-802-1; the proponent agency is USACE.

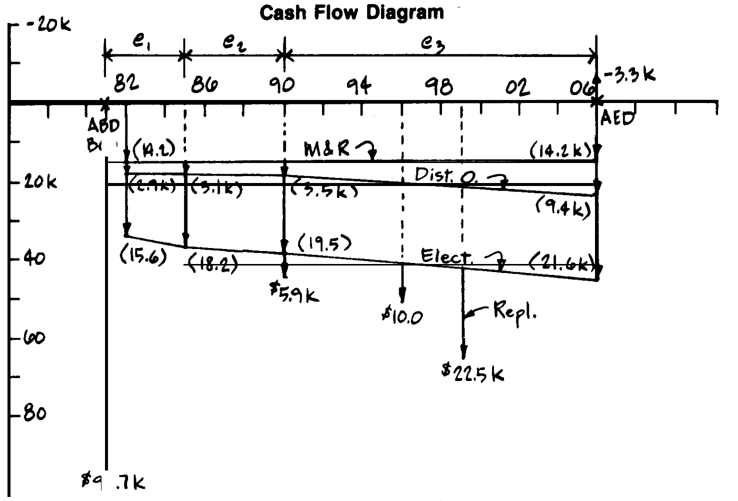
Project No. & Title PN 175 (FY84) Admin. Bldg.
Installation & Location ABCDE Ammo. Plant, Miss.
Design Feature HVAC System : Energy Conservation
Alt. No. B Title Const. Vol. w/ Recip. Chiller (setback & economy cycle)

Criteria Reference		FEMP
Date of Study (DOS)		1 Jan 82
Analysis Base Date (ABD)		1 Jul 81
Analysis End Date (AED)		1 Jul 06
Midpoint of Construction		N.A.
Beneficial Occupancy Date (BOD)	Actual Projected	1 Jan 85
	Assumed for Analysis	1 Jul 81
DOE Region		4
Annual Discount Rate		7%

Type of Cost	Differential Escalation Rate per Year (%)		
	Timeframe: Jul - Jun		
	81-85	85-90	90-06
Elect.	5.28	1.41	0.63
Dist. O.	2.52	2.64	6.35
Other	0.00	0.00	0.00

Principal Assumptions

Cash Flow Diagram



Note : Time lines denote 1 Jul of year shown

Cost Element	Cost on ABD ☒ $ x 10³ ☐ $ x 10⁶	Time Cost Incurred** Actual Projected Dates	Time Cost Incurred** Dates for Analysis (If Different)*	Source(s) of Data
Initial Investment Cost	93.7 (104.1 less 10%)	1 Jul 84	1 Jul 81	Engineer's Project Estimate
Replacement (Plant) yr. 9	5.9	1 Jan 94	1 Jul 90	Eng. Est. - Backup Sheet
Replacement (Fan) yr. 15	10.0	1 Jan 00	1 Jul 96	Eng. Est. - Backup Sheet
Replacement (Plant) yr. 18	22.5	1 Jan 03	1 Jul 99	Eng. Est. - Backup Sheet
Salvage yr. 25	- 3.3	1 Jan 10	1 Jul 06	Eng. Est. - Backup Sheet
Elect.	14.8	1 Jul 85 - 1 Jul 09	1 Jul 82 - 1 Jul 06	BLAST Program Estimate
Dist. O.	2.8	1 Jul 85 - 1 Jul 09	1 Jul 82 - 1 Jul 06	BLAST Program Estimate
M&R	14.2	1 Jul 85 - 1 Jul 09	1 Jul 82 - 1 Jul 06	Eng. Est. - Backup Sheet

DA FORM 5605-3-R, DEC 86

*When 10 CFR436A Criteria Apply
**For Recurring Annual Costs, show date of first and last costs only.

Sheet ______ of ______

Project No. Title PN 175 (FY84) Admin. Bldg.

Installation .ocation ABCDE Ammo. Plant, Miss.

Design Feature HVAC System : Energy Conservation

Alt. No. B Title Const. Vol. w/ Recip. Chiller (setback & economy cycle)

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: CONVENTIONAL APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE

Criteria Reference	FEMP
Analysis Base Date (ABD)	1 Jul 81
Analysis End Date (AED)	1 Jul 06
Midpoint of Construction	N.A.
BOD for Analysis	1 Jul 81
Annual Discount Rate	7%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: Jul - Jun 81-85	85-90	90-06
Elect.	5.28	1.41	0.63
Dist. O.	2.52	2.64	0.35
Other	0.00	0.00	0.00

One-Time Costs ☒ $ x 10³ ☐ $ x 10⁶	Years From ABD	Cost on ABD	Escalation Factor	Escal. Cost (Time Incurred)	Discount Factor	Present Worth on ABD
Net Investment Cost	0	93.7	$(1.0)^0$	93.7	1.0	93.7
Replacement (Plant) yr. 9	9	5.9	$(1.0)^9$	5.9	$(\frac{1}{1.07})^9=0.544$	3.2
Replacement (Fan) yr. 15	15	10.0	$(1.0)^{15}$	10.0	$(\frac{1}{1.07})^{15}=0.362$	3.6
Replacement (Plant) yr. 18	18	22.5	$(1.0)^{18}$	22.5	$(\frac{1}{1.07})^{18}=0.296$	6.7
Salvage yr. 25	25	-3.3	$(1.0)^{25}$	-3.3	$(\frac{1}{1.07})^{25}=0.184$	-0.6

Annual Costs ☒ $ x 10³ ☐ $ x 10⁶	Years from ABD: First Incurred	Years from ABD: Last Incurred	Total No. of Payments	Annual Cost on ABD	Escalation Factor	Escal. Cost (Time First Incurred): 1st Ann. Cost in Series	Annual Series Eq Factor	Equiv. Single Cost	Discount Factor	Present Worth on ABD
Elect. ① 82-84	1.0	3.0	3	14.8	$(1.0528)^1$	15.6	2.952	46.1	$(\frac{1}{1.07})^1=0.9346$	43.1
② 85-89	4.0	8.0	5	14.8	$(1.0528)^4$	18.2	4.504	82.0	0.7629	62.6
③ 90-06	9.0	25.0	17	14.8	$(1.0528)^4(1.0141)^5$	19.5	10.888	212.3	0.5439	115.5
Dist. O. ① 82-84	1.0	3.0	3	2.8	$(1.0252)^1$	2.9	2.876	8.3	0.9346	7.8
② 85-89	4.0	8.0	5	2.8	$(1.0252)^4$	3.1	4.609	14.3	0.7629	10.9
③ 90-06	9.0	25.0	17	2.8	$(1.0252)^4(1.0264)^5$	3.5	16.211	56.7	0.5439	30.8
M&R	1.0	25.0	25	14.2	$(1.0)^1$	14.2	12.469	177.1	0.9346	165.5

	Initial Costs		Energy/Fuel Costs		M&R Costs		Other Costs		Total
Net Present Worth:	94	+	271	+	166	+	13	=	544

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Sheet______ ______

LIFE CYCLE COST ANALYSIS
BASIC INPUT DATA SUMMARY

For use of this form, see TM 5-802-1; the proponent agency is USACE.

Project No. & Title PN 175 (FY84) Admin. Bldg.

Installation & Location AECDE Ammo. Plant, Miss.

Design Feature HVAC System : Energy Conservation

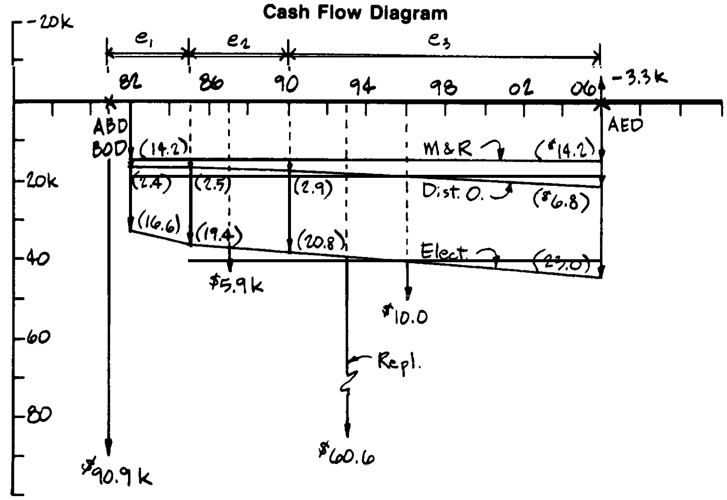
Alt. No. C **Title** Const. Vol. w/ Dbl. Bundle Chiller (no setback, no economy cycle)

Criteria Reference		FEMP
Date of Study (DOS)		1 Jan 82
Analysis Base Date (ABD)		1 Jul 81
Analysis End Date (AED)		1 Jul 06
Midpoint of Construction		N.A.
Beneficial Occupancy Date (BOD)	Actual Projected	1 Jan 85
	Assumed for Analysis	1 Jul 81
DOE Region		4
Annual Discount Rate		7%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: Jul - Jun		
	81-85	85-90	90-06
Elect.	5.28	1.41	0.63
Dist. O.	2.52	2.64	6.35
Other	0.00	0.00	0.00

Principal Assumptions

Cash Flow Diagram



Note: Time lines denote 1 Jul of year shown

Cost Element	Cost on ABD ☒ $ x 10³ ☐ $ x 10⁶	Time Cost Incurred** Actual Projected Dates	Dates for Analysis (If Different)*	Source(s) of Data
Initial Investment Cost	90.9 (101.0 less 10%)	1 Jul 84	1 Jul 81	Engineer's Project Estimate
Replacement (Plant) yr. 6	5.9	1 Jan 91	1 Jul 87	Eng. Est. - Backup Sheet
Replacement (Plant) yr. 12	60.6	1 Jan 97	1 Jul 93	Eng. Est. - Backup Sheet
Replacement (Fan) yr. 15	10.0	1 Jan 00	1 Jul 96	Eng. Est. - Backup Sheet
Salvage yr. 25	-3.3	1 Jan 10	1 Jul 06	Eng. Est. - Backup Sheet
Elect.	15.8	1 Jul 85 - 1 Jul 09	1 Jul 82 - 1 Jul 06	BLAST Program Estimate
Dist. O.	2.3	1 Jul 85 - 1 Jul 09	1 Jul 82 - 1 Jul 06	BLAST Program Estimate
M&R	14.2	1 Jul 85 - 1 Jul 09	1 Jul 82 - 1 Jul 06	Eng. Est. - Backup Sheet

DA FORM 5605-3-R, DEC 86

*When 10 CFR436A Criteria Apply

**For Recurring Annual Costs, show date of first and last costs only.

Sheet ______ of ______

Project No. & Title PN 175 (FY84) Admin. Bldg.
Installation & Location ABCDE Ammo. Plant, Miss.
Design Feature HVAC System: Energy Conservation
Alt. No. C Title Const. Vol. w/ Dbl. Bundle Chiller
(no setback, no economy cycle)

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: CONVENTIONAL APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

One-Time Costs ☒ $ x 10³ ☐ $ x 10⁶	Years From ABD	Cost on ABD	Escalation Factor	Escal.Cost (Time Incurred)	Discount Factor	Present Worth on ABD
Net Investment Cost	0	90.9	$(1.0)^0$	90.9	$(\frac{1}{1.07})^0=1.0$	90.9
Replacement (Plant) yr. 6	6	5.9	$(1.0)^6$	5.9	$(\frac{1}{1.07})^6=0.666$	3.9
Replacement (Fan) yr. 12	12	60.6	$(1.0)^{12}$	60.6	$(\frac{1}{1.07})^{12}=0.444$	26.9
Replacement (Plant) yr. 15	15	0.0	$(1.0)^{15}$	10.0	$(\frac{1}{1.07})^{15}=0.362$	3.6
Salvage yr. 25	25	-3.3	$(1.0)^{25}$	-3.3	$(\frac{1}{1.07})^{25}=0.184$	-0.6

Criteria Reference	FEMP
Analysis Base Date (ABD)	1 Jul 81
Analysis End Date (AED)	1 Jul 06
Midpoint of Construction	N.A.
BOD for Analysis	1 Jul 81
Annual Discount Rate	7%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: Jul-Jun 81-85	85-90	90-06
Elect.	5.28	1.41	0.63
Dist. O.	2.52	2.64	6.35
Other	0.00	0.00	0.00

Annual Costs ☒ $ x 10³ ☐ $ x 10⁶	Years from ABD: First Incurred	Years from ABD: Last Incurred	Total No. of Payments	Annual Cost on ABD	Escalation Factor	Escal.Cost (Time First Incurred): 1st Ann. Cost in Series	Annual Series Eq Factor	Equiv. Single Cost	Discount Factor	Present Worth on ABD
Elect. ① 82-84	1.0	3.0	3	15.8	$(1.0528)^1$	16.6	2.952	49.0	0.9346	45.8
② 85-89	4.0	8.0	5	15.8	$(1.0528)^4$	19.4	4.504	87.4	0.7629	66.7
③ 90-06	9.0	25.0	17	15.8	$(1.0528)^4(1.0141)^5$	20.8	10.888	226.5	0.5439	123.2
Dist. O. ① 82-84	1.0	3.0	3	2.3	$(1.0252)^1$	2.4	2.876	6.9	0.9346	6.4
② 85-89	4.0	8.0	5	2.3	$(1.0252)^4$	2.5	4.609	11.5	0.7629	8.8
③ 90-06	9.0	25.0	17	2.3	$(1.0252)^4(1.0264)^5$	2.9	16.211	47.0	0.5439	25.6
M&R	1.0	25.0	25	14.2	$(1.0)^1$	14.2	12.469	177.1	0.9346	165.5

	Initial Costs	Energy/Fuel Costs	M&R Costs	Other Costs	Total
Net Present Worth:	91	277	166	34	568

DA FORM 5605-4-R, DEC 86

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LIFE CYCLE COST ANALYSIS
BASIC INPUT DATA SUMMARY

For use of this form, see TM 5-802-1; the proponent agency is USACE.

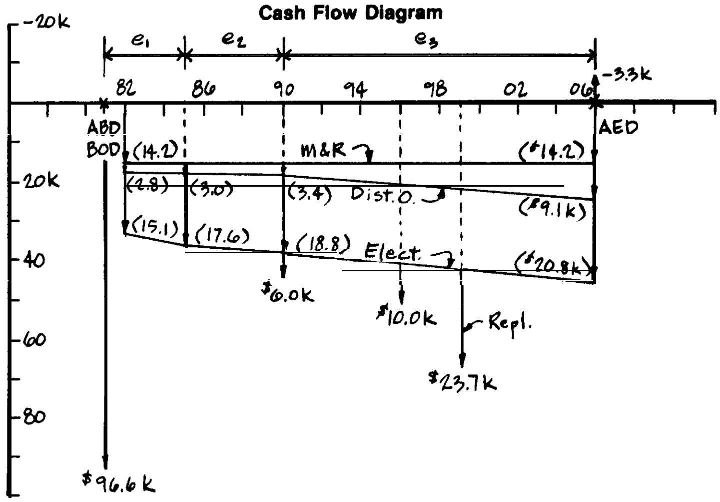
Project No. & Title PN 175 (FY84) Admin. Bldg.
Installation & Location ABCDE Ammo. Plant, Miss.
Design Feature HVAC System : Energy Conservation
Alt. No. D **Title** Const. Vol. w/ Dbl. Bundle Chiller (setback & economy cycle)

Criteria Reference		FEMP
Date of Study (DOS)		1 Jan 82
Analysis Base Date (ABD)		1 Jul 81
Analysis End Date (AED)		1 Jul 06
Midpoint of Construction		N.A.
Beneficial Occupancy Date (BOD)	Actual Projected	1 Jan 85
	Assumed for Analysis	1 Jul 81
DOE Region		4
Annual Discount Rate		7%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: Jul - Jun 81-85	85-90	90-06
Elect.	5.28	1.41	0.63
Dist. O.	2.52	2.64	6.35
Other	0.00	0.00	0.00

Principal Assumptions

Cash Flow Diagram



Note: Time lines denote 1 Jul of year shown

Cost Element	Cost on ABD ☒ $ x 10³ ☐ $ x 10⁶	Time Cost Incurred** Actual Projected Dates	Dates for Analysis (If Different)*	Source(s) of Data
Initial Investment Cost	96.6 (107.3 less 10%)	1 Jul 84	1 Jul 81	Engineer's Project Estimate
Replacement (Plant) yr. 9	6.0	1 Jan 94	1 Jul 90	Eng. Est. - Backup Sheet
Replacement (Fan) yr 15	10.0	1 Jan 00	1 Jul 96	Eng. Est. - Backup Sheet
Replacement (Plant) yr 18	23.7	1 Jan 03	1 Jul 99	Eng. Est. - Backup Sheet
Salvage yr. 25	-3.3	1 Jan 10	1 Jul 06	Eng. Est. - Backup Sheet
Elect.	14.3	1 Jul 85 - 1 Jul 09	1 Jul 82 - 1 Jul 06	BLAST Program Estimate
Dist. O.	2.7	1 Jul 85 - 1 Jul 09	1 Jul 82 - 1 Jul 06	BLAST Program Estimate
M&R	14.2	1 Jul 85 - 1 Jul 09	1 Jul 82 - 1 Jul 06	Eng. Est. - Backup Sheet

DA FORM 5605-3-R, DEC 86

*When 10 CFR436A Criteria Apply
**For Recurring Annual Costs, show date of first and last costs only

Sheet________ of________

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: CONVENTIONAL APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

Project No. & Title PN 175 (FY84) Admin. Bldg.

Installation Location ABCDE Ammo. Plant, Miss.

Design Feature HVAC System: Energy Conservation

Alt. No. D Title Const. Vol. w/Dbl. Bundle Chiller (setback & economy cycle)

One-Time Costs ☒ $ x 10³ ☐ $ x 10⁶	Years From ABD	Cost on ABD	Escalation Factor	Escal. Cost (Time Incurred)	Discount Factor	Present Worth on ABD
Net Investment Cost	0	96.6	$(1.0)^0$	96.6	$\left(\frac{1}{1.07}\right)^0=1.0$	96.6
Replacement (Plant) yr. 9	9	6.0	$(1.0)^9$	6.0	$\left(\frac{1}{1.07}\right)^9=0.544$	3.3
Replacement (Fan) yr. 15	15	10.0	$(1.0)^{15}$	10.0	$\left(\frac{1}{1.07}\right)^{15}=0.362$	3.6
Replacement (Plant) yr. 18	18	23.7	$(1.0)^{18}$	23.7	$\left(\frac{1}{1.07}\right)^{18}=0.296$	7.0
Salvage yr. 25	25	-3.3	$(1.0)^{25}$	-3.3	$\left(\frac{1}{1.07}\right)^{25}=0.184$	-0.6

Criteria Reference	FEMP
Analysis Base Date (ABD)	1 Jul 81
Analysis End Date (AED)	1 Jul 06
Midpoint of Construction	N.A.
BOD for Analysis	1 Jul 81
Annual Discount Rate	7%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: Jul-Jun 81-85	85-90	90-06
Elect.	5.28	1.41	0.63
Dist. O.	2.52	2.64	6.35
Other	0.00	0.00	0.00

Annual Costs ☒ $ x 10³ ☐ $ x 10⁶	Years from ABD: First Incurred	Last Incurred	Total No. of Payments	Annual Cost on ABD	Escalation Factor	Escal. Cost (Time First Incurred): 1st Ann. Cost in Series	Annual Series Eq Factor	Equiv. Single Cost	Discount Factor	Present Worth on ABD
Elect. ① 82-84	1.0	3.0	3	14.3	$(1.0528)^1$	15.1	2.952	44.6	0.9346	41.7
② 85-89	4.0	8.0	5	14.3	$(1.0528)^4$	17.6	4.504	79.3	0.7629	60.5
③ 90-06	9.0	25.0	17	14.3	$(1.0528)^4(1.0141)^5$	18.8	10.888	204.7	0.5439	111.3
Dist. O. ① 82-84	1.0	3.0	3	2.7	$(1.0252)^1$	2.8	2.876	8.1	0.9346	7.6
② 85-89	4.0	8.0	5	2.7	$(1.0252)^4$	3.0	4.609	13.8	0.7629	10.5
③ 90-06	9.0	25.0	17	2.7	$(1.0252)^4(1.0264)^5$	3.4	16.211	55.1	0.5439	30.0
M&R	1.0	25.0	25	14.2	$(1.0)^1$	14.2	12.469	177.1	0.9346	165.5

	Initial Costs		Energy/Fuel Costs		M&R Costs		Other Costs		Total
Net Present Worth:	97	+	262	+	166	+	13	=	538

DA FORM 5605-4-R, DEC 86

Sh ______ ______

Project No. & Title PN 175 (FY84) Admin. Bldg.
Installation & Location ABCDE Ammo. Plant, Miss.
Design Feature HVAC System : Energy Conservation

Date of Study 1 Jan 82

LIFE CYCLE COST ANALYSIS
SUMMARY

For use of this form, see TM 5-802-1; the proponent agency is USACE.

ALTERNATIVES ANALYZED						
No.	Description/Title	Present Worth ☒ $ x 10³ ☐ $ x 10⁶				
		Initial	Energy	M&R	Other	Total
A	Const. Vol. w/ Recip. Chiller (no SB/EC)	88	297	166	23	574
B	Const. Vol w/ Recip. Chiller (with SB/EC)	94	271	166	13	544
C	Const Vol w/ Dbl. Bundle Chiller (no SB/EC)	91	277	166	34	568
D	Const. Vol w/ D. Bundle Chiller (with SB/EC)	97	262	166	13	538

ECONOMIC RANKING				
Rank	Alternative No. & Title	Economic Advantages of Top-Ranked Alternative		Basis for No. 1 Ranking
		LCC (PW) Difference (Dollars & Percent)	Other (Initial, Energy, Etc.)	
1 2 3 4	D Const Vol w/ D. Bun. Chill (with SB/EC) B Const. Vol w/ Recip. Chill (with SB/EC) C Const. Vol w/ D. Bun. Chill (no SB/EC) A Const. Vol w/ R. Chill (no SB/EC)	$6,000, 1%	Lower energy consumption	Designer's Choice

KEY ASSUMPTIONS	NARRATIVE SUMMARY (Comments/Lessons Learned/Observations/Recommendations/Etc.)

Key Participants - Name	Discipline	Organization	Telephone No.
William Smith, PE (Major USA Ret.)	Mechanical	A-E Associates	(601) 555-3000
Rosevelt Brown, PE	Electrical	A-E Associates	(601) 555-3000

DA FORM 5605-2-R, DEC 86

Sheet ______ of ______

DOMESTIC HOT WATER HEATING SYSTEM: ENERGY

CONSERVATION (SOLAR)

Project No. & Title PN 175 (FY84) Admin. Bldg.
Installation & Location ABCDE Ammo. Plant, Miss.
Design Feature Domestic Hot Water Heating System
Alt. No. B-A **Title** Solar System Increment

LIFE CYCLE COST ANALYSIS
BASIC INPUT DATA SUMMARY

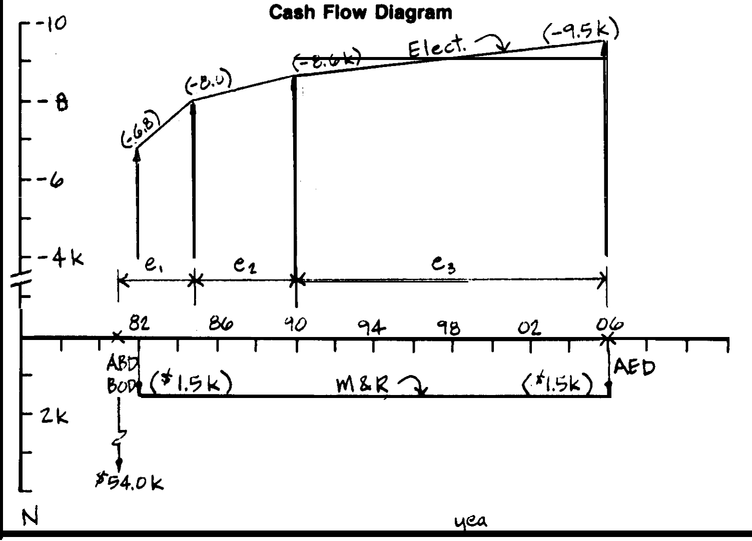
For use of this form, see TM 5-802-1; the proponent agency is USACE.

Criteria Reference		FEMP
Date of Study (DOS)		1 Jan 82
Analysis Base Date (ABD)		1 Jul 81
Analysis End Date (AED)		1 Jul 06
Midpoint of Construction		N.A.
Beneficial Occupancy Date (BOD)	Actual Projected	1 Jan 85
	Assumed for Analysis	1 Jul 81
DOE Region		4
Annual Discount Rate		7%

Type of Cost	Differential Escalation Rate per Year (%)		
	Timeframe: Jul – Jun		
	81-85	85-90	90-06
Elect.	5.28	1.41	0.63
Other	0.00	0.00	0.00

Principal Assumptions

Cash Flow Diagram



Cost Element	Cost on ABD ☒ $ x 10³ ☐ $ x 10⁶	Time Cost Incurred** Actual Projected Dates	Time Cost Incurred** Dates for Analysis (If Different)*	Source(s) of Data
Initial Investment Cost	54.0 (60.0 less 10%)	1 Jul 84	1 Jul 81	Engineer's Project Estimate
Elect.	-6.5	1 Jul 85 - 1 Jul 04	1 Jul 82 - 1 Jul 06	Eng. Est. – Backup Sheet
M&R	1.5	1 Jul 85 - 1 Jul 04	1 Jul 82 - 1 Jul 06	Eng. Est. – Backup Sheet

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*When 10 CFR436A Criteria Apply
**For Recurring Annual Costs, show date of first and last costs only.

Sheet ______ of ______

Project No. & Title PN 175 (FY 84) Admin. Bldg.
Installation & Location ABCDE Ammo. Plant, Miss.
Design Feature Domestic Hot Water Heating System
Alt. No. B-A Title Solar System Increment

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: CONVENTIONAL APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

One-Time Costs ☒ $ x 10³ ☐ $ x 10⁶	Years From ABD	Cost on ABD	Escalation Factor	Escal. Cost (Time Incurred)	Discount Factor	Present Worth on ABD
Initial Investment Cost	0	54.0	$(1.0)^0$	54.0	$(1+i)^0 = 1.0$	54.0

Criteria Reference	FEMP
Analysis Base Date (ABD)	1 Jul 81
Analysis End Date (AED)	1 Jul 06
Midpoint of Construction	N A
BOD for Analysis	1 Jul 81
Annual Discount Rate	7%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: Jul - Jun 81-85	85-90	90-06
Elect.	5.28	1.41	0.63
Other	0.00	0.00	0.00

Annual Costs ☒ $ x 10³ ☐ $ x 10⁶	Years from ABD: First Incurred	Years from ABD: Last Incurred	Total No. of Payments	Annual Cost on ABD	Escalation Factor	Escal. Cost (Time First Incurred): 1st Ann. Cost in Series	Annual Series Eq Factor	Equiv. Single Cost	Discount Factor	Present Worth on ABD
Elect. (1) 82-84	1.0	3.0	3	-6.5	$(1.0528)^1$	-6.8	2.952	-20.1	0.9346	-18.8
(2) 85-89	4.0	8.0	5	-6.5	$(1.0528)^4$	-8.0	4.504	-36.0	0.7629	-27.5
(3) 90-06	9.0	25.0	17	-6.5	$(1.0528)^4(1.0141)^5$	-8.6	10.888	-93.6	0.5439	-50.9
M&R	1.0	25.0	25	1.5	$(1.0)^1$	1.5	12.469	18.7	0.9346	17.5

	Initial Costs		Energy/Fuel Costs		M&R Costs		Other Costs		Total
Net Present Worth	54.0	+	-97.2	+	17.5	+	0.0	=	-25.7

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Sheet _____ of _____

Project No. & Title PN 175 (FY84) Admin. Bldg.
Installation & Location ABCDE Ammo. Plant, Miss.
Design Feature Domestic Hot Water Heating System
Baseline System Elect. Hot Water Heating Syst.
Investment Solar Hot Water Heating

LIFE CYCLE COST ANALYSIS

SAVINGS-TO-INVESTMENT RATIO (SIR) & DISCOUNTED PAYBACK CALCULATION

For use of this form, see TM 5-802-1; the proponent agency is USACE.

SIR Calculation				Discounted Payback Calculation				
				Trial Values of Post-BOD Analysis Period, n(years)				
Element of Calculation	System	Type of Cost/Benefit		n = 17	n = 12	n = 13	n =	n =
PW of Operating & Maintenance Costs ☒ $ x 10³ ☐ $ x 10⁶	Baseline	Energy/Fuel						
		Other O&M						
		Total						
	Investment	Energy/Fuel						
		Other O&M						
		Total						
	Δ	Net Savings	79.7	65.1	51.5	54.6		
PW of Capital Costs ☒ $ x 10³ ☐ $ x 10⁶	Baseline	Initial (MCP)						
		Replacements						
		Terminal						
		Other						
		Total Net						
	Investment	Initial (MCP)						
		Replacements						
		Terminal						
		Other						
		Total Net						
	−Δ	Extra Investment	54.0	54.0	54.0	54.0		
SIR	Δ	Net Savings / Extra Investment	$\frac{79.7}{54.0} = 1.5$	$\frac{65.1}{54.0} = 1.2$	$\frac{51.5}{54.0} = 0.95$	$\frac{54.6}{54.0} = 1.01$		
Next Trial n Value (Years)		A = This SIR — 1.0	0.5	0.2	−0.05			
		B = This SIR — Last SIR*	1.5	−0.3	−0.25			
		C = Ratio of A to B	0.33	−0.67	+0.2			
		D = Last n* — This n	−25	8	5			
		E = Product of C & D	−8.3	−5.4	+1			
		F = Next n = This n + E	16.7	12	13			

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*In calculating First Trial n Value for Discounted Payback Calculation, Use Last SIR = Last n = 0.

Sheet ______ of ______

LIFE CYCLE COST ANALYSIS
SUMMARY

Project No. & Title PN 175 (FY84) Admin. Bldg.
Installation & Location ABCDE Ammo. Plant, Miss.
Design Feature Domestic Hot Water Heating System

For use of this form, see TM 5-802-1; the proponent agency is USACE.

Date of Study 1 Jan 82

ALTERNATIVES ANALYZED						
No.	Description/Title	Present Worth ☒ $ x 10³ ☐ $ x 10⁶				
		Initial	Energy	M&R	Other	Total
A	Elect. Hot Water Heating Alone	–	–	–	–	–
B	Solar Heating w/ Elect. Backup	–	–	–	–	–
B-A	Solar System Increment	54.0	-97.2	17.5	0.0	-25.7

ECONOMIC RANKING				
Rank	Alternative No. & Title	Economic Advantages of Top-Ranked Alternative: LCC (PW) Difference (Dollars & Percent)	Economic Advantages of Top-Ranked Alternative: Other (Initial, Energy, Etc.)	Basis for No. 1 Ranking
1	B Solar Heating w/ Elect. Backup			
2	A Elect. Hot Water Heating Alone	$25,700	Lower energy consumption	Lower LCC

KEY ASSUMPTIONS	NARRATIVE SUMMARY (Comments/Lessons Learned/Observations/Recommendations/Etc.)
	Savings-to-Investment Ratio (SIR) = 1.5
	Discounted Payback Period (DPP) = 13 years

Key Participants - Name	Discipline	Organization	Telephone No.
Rosevelt Brown, PE	Electrical	A-E Associates	(601) 555-3000
Stephen Kirk, AIA	Architectural	A-E Associates	(601) 555-3000

DA FORM 5605-2-R, DEC 86

Sh ______ ______

WASTEWATER TREATMENT FACILITY

Project No. & Title PN 003 (FY 84) Wastewater T.F.
Installation & Location Fort Oaks, Alabama
Design Feature Process
Alt. No. A Title Conventional Trickling Filter

LIFE CYCLE COST ANALYSIS
BASIC INPUT DATA SUMMARY

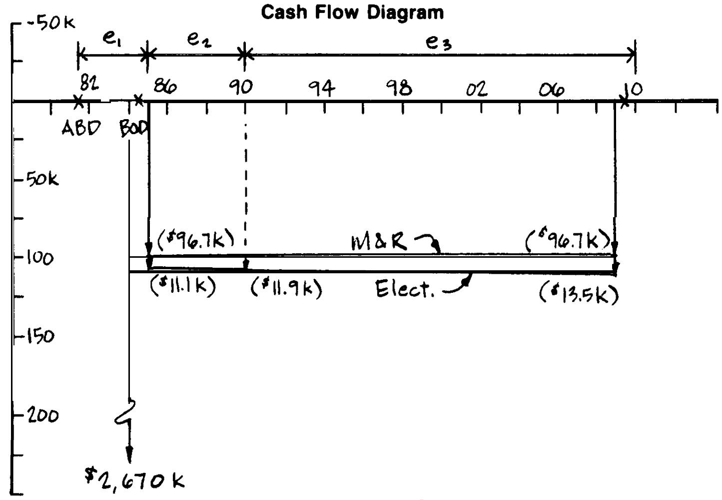
For use of this form, see TM 5-802-1; the proponent agency is USACE.

Criteria Reference		HQDA
Date of Study (DOS)		1 Jan 82
Analysis Base Date (ABD)		1 Jan 82
Analysis End Date (AED)		1 Jan 10
Midpoint of Construction		1 Jul 84
Beneficial Occupancy Date (BOD)	Actual Projected	1 Jan 85
	Assumed for Analysis	1 Jan 85
DOE Region		4
Annual Discount Rate		10%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: Jul - Jun		
	82-85	85-90	90-10
Elect.	5.28	1.41	0.63
Other	0.00	0.00	0.00

Principal Assumptions

Cash Flow Diagram



Note: Time lines denote 1 Jul of year shown

Cost Element	Cost on ABD ☒ \$ x 10³ ☐ \$ x 10⁶	Time Cost Incurred** Actual Projected Dates	Time Cost Incurred** Dates for Analysis (If Different)*	Source(s) of Data
Initial Investment Cost	2,670	1 Jul 84		Engineer's Project Estimate
Elect.	9.3	1 Jul 85 - 1 Jul 09		BLAST Program Estimate
M&R	96.7	1 Jul 85 - 1 Jul 09		Eng. Est. - Backup Sheet

DA FORM 5605-3-R, DEC 86

*When 10 CFR436A Criteria Apply
**For Recurring Annual Costs, show date of first and last costs only.

Sheet ______ of ______

Project No. & Title: PN 003 (FY 84) Wastewater T.F.
Installation & Location: Fort Oaks, Alabama
Design Feature: Process
Alt. No.: A Title: Conventional Trickling Filter

LIFE CYCLE COST ANALYSIS
PRESENT WORTH: CONVENTIONAL APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

One-Time Costs (☒ \$ x 10^3 ☐ \$ x 10^6)	Years From ABD	Cost on ABD	Escalation Factor	Escal.Cost (Time Incurred)	Discount Factor	Present Worth on ABD
Initial Investment Cost	2.5	2670	$(1.0)^{2.5}$	2670	$\left(\frac{1}{1.1}\right)^{2.5}=0.788$	2104

Criteria Reference	HQDA
Analysis Base Date (ABD)	1 Jan 82
Analysis End Date (AED)	1 Jan 10
Midpoint of Construction	1 Jul 84
BOD for Analysis	1 Jan 85
Annual Discount Rate	10%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: Jul-Jun 82-85	85-90	90-10
Elect.	5.28	1.41	0.63
Other	0.00	0.00	0.00

Annual Costs (☒ \$ x 10^3 ☐ \$ x 10^6)	Years from ABD: First Incurred	Last Incurred	Total No. of Payments	Annual Cost on ABD	Escalation Factor	Escal.Cost (Time First Incurred): 1st Ann. Cost in Series	Annual Series Eq Factor	Equiv. Single Cost	Discount Factor	Present Worth on ABD
Elect. ① 85-89	3.5	7.5	5	9.3	$(1.0528)^{3.5}$	11.1	4.278	47.5	$\left(\frac{1}{1.1}\right)^{3.5}=0.7164$	34.0
② 90-09	8.5	27.5	20	9.3	$(1.0528)^{3.5}(1.041)^{5}$	11.9	9.768	116.2	$\left(\frac{1}{1.1}\right)^{8.5}=0.4448$	51.7
M&R	3.5	27.5	25	96.7	$(1.0)^{3.5}$	96.7	9.986	965.5	0.7164	691.7

	Initial Costs		Energy/Fuel Costs		M&R Costs		Other Costs		Total
Net Present Worth:	2104	+	86	+	692	+	0	=	2882

DA FORM 5605-4-R, DEC 86

Sheet____ of ____

Project No. & Title PN 003 (FY84) Wastewater T. F.
Installation & Location Fort Oaks, Alabama
Design Feature Process
Alt. No. B Title Innovative: Rotating Biological Contactors (RBC)

LIFE CYCLE COST ANALYSIS
BASIC INPUT DATA SUMMARY

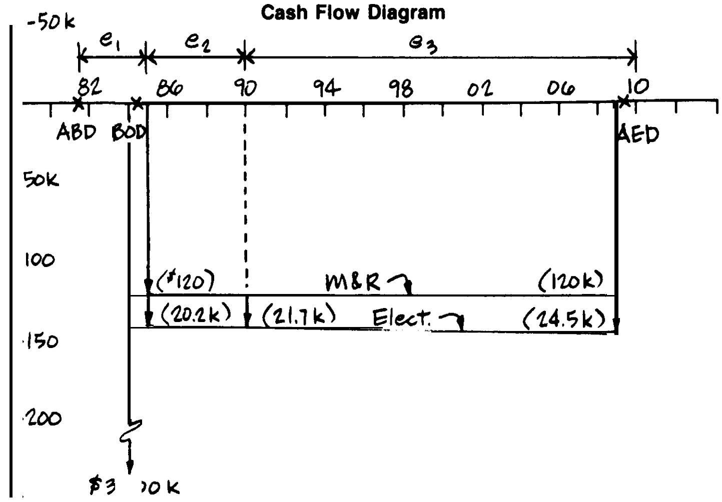
For use of this form, see TM 5-802-1; the proponent agency is USACE.

Criteria Reference		HQDA
Date of Study (DOS)		1 Jan 82
Analysis Base Date (ABD)		1 Jan 82
Analysis End Date (AED)		1 Jan 10
Midpoint of Construction		1 Jul 84
Beneficial Occupancy Date (BOD)	Actual Projected	1 Jan 85
	Assumed for Analysis	1 Jan 85
DOE Region		4
Annual Discount Rate		10%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: Jul - Jun		
	82-85	85-90	90-10
Elect.	5.28	1.41	0.63
Other	0.00	0.00	0.00

Principal Assumptions

Cash Flow Diagram



Note: Time lines denote 1 Jul of year shown

Cost Element	Cost on ABD ☒ $ x 10³ ☐ $ x 10⁶	Time Cost Incurred** Actual Projected Dates	Time Cost Incurred** Dates for Analysis (If Different)*	Source(s) of Data
Initial Investment Cost	3,600	1 Jul 84		Engineer's Project Estimate
Elect.	16.9	Jul 85 - 1 Jul 09		BLAST Program Estimate
M&R	120	Jul 85 - 1 Jul 09		Eng. Est. - Backup Sheet

DA FORM 5605-3-R, DEC 86

*When 10 CFR436A Criteria Apply
**For Recurring Annual Costs, show date of first and last costs only.

Sheet ______ of ______

Project No. & Title PN 003 (FY84) Wastewater T.F.

Installation & Location Fort Oaks, Alabama

Design Feature Process

Alt. No. B Title Innovative: Rotating Biological Contactors (RBC)

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: CONVENTIONAL APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

One-Time Costs ☒ $ x 10³ ☐ $ x 10⁶	Years From ABD	Cost on ABD	Escalation Factor	Escal.Cost (Time Incurred)	Discount Factor	Present Worth on ABD
Initia Investment Cost	2.5	3600	$(1.0)^{2.5}$	3600	$(\frac{1}{1.1})^{2.5}=0.788$	2837

Criteria Reference	HQDA
Analysis Base Date (ABD)	1 Jan 82
Analysis End Date (AED)	1 Jan 10
Midpoint of Construction	1 Jul 84
BOD for Analysis	1 Jan 85
Annual Discount Rate	10%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: Jul-Jun 82-85	85-90	90-10
Elect.	5.28	1.41	0.63
Other	0.00	0.00	0.00

Annual Costs ☒ $ x 10³ ☐ $ x 10⁶	Years from ABD: First Incurred	Last Incurred	Total No. of Payments	Annual Cost on ABD	Escalation Factor	Escal.Cost (Time First Incurred): 1st Ann. Cost in Series	Annual Series Eq Factor	Equiv. Single Cost	Discount Factor	Present Worth on ABD
Elect. (1) 85-89	3.5	7.5	5	16.9	$(1.0528)^{3.5}$	20.2	4.278	86.4	$(\frac{1}{1.1})^{3.5}=0.7164$	61.9
(2) 90-09	8.5	27.5	20	16.9	$(1.0528)^{3.5}(1.0141)^{5}$	21.7	9.768	212.0	$(\frac{1}{1.1})^{8.5}=0.4448$	94.3
M&R	3.5	27.5	25	120	$(1.0)^{3.5}$	120	9.985	1198	0.7164	58

	Initial Costs		Energy/Fuel Costs		M&R Costs		Other Costs		Total
Net Present Worth:	2837	+	156	+	858	+	0	=	3851

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LIFE CYCLE COST ANALYSIS
BASIC INPUT DATA SUMMARY

For use of this form, see TM 5-802-1; the proponent agency is USACE.

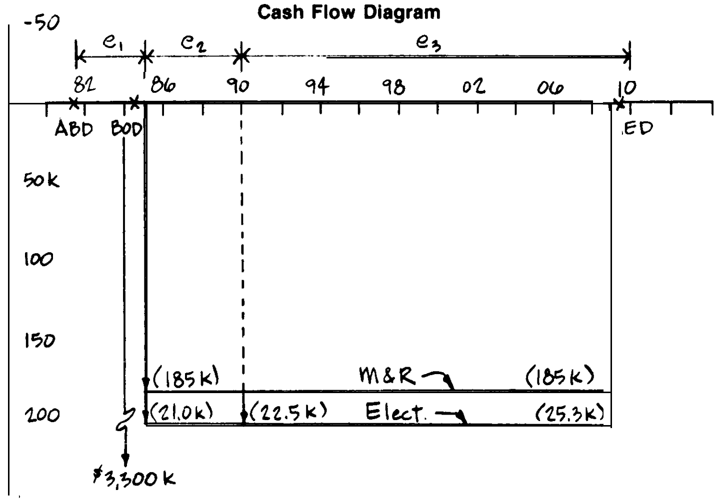
Project No. & Title PN 003 (FY 84) Wastewater T.F.
Installation & Location Fort Oaks, Alabama
Design Feature Process
Alt. No. C Title Innovative: Continuous Loop Reactor

Criteria Reference		HQDA
Date of Study (DOS)		1 Jan 82
Analysis Base Date (ABD)		1 Jan 82
Analysis End Date (AED)		1 Jan 10
Midpoint of Construction		1 Jul 84
Beneficial Occupancy Date (BOD)	Actual Projected	1 Jan 85
	Assumed for Analysis	1 Jan 85
DOE Region		4
Annual Discount Rate		10%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: Jul - Jun		
	82-85	85-90	90-10
Elect.	5.28	1.41	0.63
Other	0.00	0.00	0.00

Principal Assumptions

Cash Flow Diagram



Note: Time lines denote 1 Jul of year shown

Cost Element	Cost on ABD ☒ $ x 10^3 ☐ $ x 10^6	Time Cost Incurred** Actual Projected Dates	Time Cost Incurred** Dates for Analysis (If Different)*	Source(s) of Data
Initial Investment Cost	3,320	1 Jul 84		Engineer's Project Estimate
Elect.	17.5	1 Jul 85 - 1 Jul 09		BLAST Program Estimate
M&R	185	1 Jul 85 - 1 Jul 09		Eng. Est. - Backup Sheet

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*When 10 CFR436A Criteria Apply
**For Recurring Annual Costs, show date of first and last costs only.

Sheet ______ of ______

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: CONVENTIONAL APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

Project No. Title PN 003 (FY84) Wastewater T.F.

Installation & Location Fort Oaks, Alabama

Design " a" Process

Alt. No. C Title Innovative: Continuous Loop Reactor

Criteria Reference	HQDA
Analysis Base Date (ABD)	1 Jan 82
Analysis End Date (AED)	1 Jan 10
Midpoint of Construction	1 Jul 84
BOD for Analysis	1 Jan 85
Annual Discount Rate	10%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: Jul - Jun 82-85	85-90	90-10
Elect.	5.28	1.41	0.63
Other	0.00	0.00	0.00

One-Time Costs ☒ $ x 10³ ☐ $ x 10⁶	Years From ABD	Cost on ABD	Escalation Factor	Escal. Cost (Time Incurred)	Discount Factor	Present Worth on ABD
Initial Investment Cost	2.5	3320	$(1.0)^{2.5}$	3320	$\left(\frac{1}{1.1}\right)^{2.5}=0.788$	2616

Annual Costs ☒ $ x 10³ ☐ $ x 10⁶	Years from ABD: First Incurred	Last Incurred	Total No. of Payments	Annual Cost on ABD	Escalation Factor	Escal. Cost (Time First Incurred): 1st Ann. Cost in Series	Annual Series Eq Factor	Equiv. Single Cost	Discount Factor	Present Worth on ABD
Elect ① 85-89	3.5	7.5	5	17.5	$(1.0528)^{3.5}$	21.0	4.278	89.8	$\left(\frac{1}{1.1}\right)^{3.5}=0.7164$	64.3
② 90-09	8.5	27.5	20	17.5	$(1.0528)^{3.5}(1.0141)^{5}$	22.5	9.768	219.8	$\left(\frac{1}{1.1}\right)^{8.5}=0.4448$	97.8
M&R	3.5	27.5	25	185		185	9.985	1847	0.7164	1323

	Initial Costs		Energy/Fuel Costs		M&R Costs		Other Costs		Total
Net Present Worth:	2616	+	162	+	1323	+	0	=	4101

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Shee ______ of ______

LIFE CYCLE COST ANALYSIS
BASIC INPUT DATA SUMMARY

For use of this form, see TM 5-802-1; the proponent agency is USACE.

Project No. & Title PN 003 (FY 84) Wastewater T.F.

Installation & Location Fort Oaks, Alabama

Design Feature Process

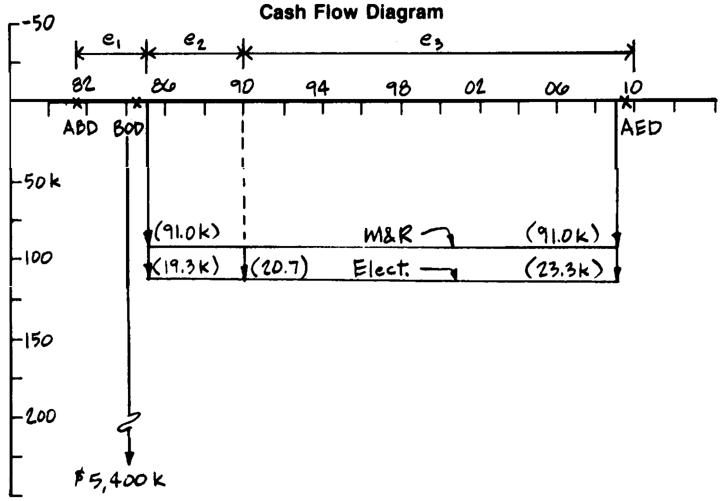
Alt. No. D **Title** Conventional: Land Spray Irrigation

Criteria Reference		HQDA
Date of Study (DOS)		1 Jan 82
Analysis Base Date (ABD)		1 Jan 82
Analysis End Date (AED)		1 Jan 10
Midpoint of Construction		1 Jul 84
Beneficial Occupancy Date (BOD)	Actual Projected	1 Jan 85
	Assumed for Analysis	1 Jan 85
DOE Region		4
Annual Discount Rate		10%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: Jul – Jun		
	82-85	85-90	90-10
Elect.	5.28	1.41	0.63
Other	0.00	0.00	0.00

Principal Assumptions

Cash Flow Diagram



Note: Time lines denote 1 Jul of year shown

Cost Element	Cost on ABD ☒ $ x 10³ ☐ $ x 10⁶	Time Cost Incurred** Actual Projected Dates	Time Cost Incurred** Dates for Analysis (If Different)*	Source(s) of Data
Initial Investment Cost ①	5,400	1 Jul 84		Engineer's Project Estimate
Elect.	16.1	1 Jul 85 - 1 Jul 09		BLAST Program Estimate
M&R	91.0	1 Jul 85 - 1 Jul 09		Eng. Est. – Backup Sheet

① Includes 500 acres of land at $[illegible]/acre

DA FORM 5605-3-R, DEC 86

*When 10 CFR436A Criteria Apply

**For Recurring Annual Costs, show date of first and last costs only.

Sheet ______ of ______

Project No. & Title PN 003 (FY84) Wastewater T.F.
Installation & Location Fort Oaks, Alabama
Design Feature Process
Alt. No. D Title Conventional : Land Spray Irrigation

LIFE CYCLE COST ANALYSIS
PRESENT WORTH: CONVENTIONAL APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

One-Time Costs ☒ $ x 10³ ☐ $ x 10⁶	Years From ABD	Cost on ABD	Escalation Factor	Escal.Cost (Time Incurred)	Discount Factor	Present Worth on ABD
Initial Investment Cost	2.5	5400	$(1.0)^{2.5}$	5400	$(\frac{1}{1.1})^{2.5} = 0.788$	4255

Criteria Reference	HQDA
Analysis Base Date (ABD)	1 Jan 82
Analysis End Date (AED)	1 Jan 10
Midpoint of Construction	1 Jul 84
BOD for Analysis	1 Jan 85
Annual Discount Rate	10%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: Jul-Jun 82-85	85-90	90-10
Elect	5.28	4	0.63
Other	0.00	0.00	0.00

Annual Costs ☒ $ x 10³ ☐ $ x 10⁶	Years from ABD First Incurred	Years from ABD Last Incurred	Total No. of Payments	Annual Cost on ABD	Escalation Factor	Escal.Cost (Time First Incurred) 1st Ann. Cost in Series	Annual Series Eq Factor	Equiv. Single Cost	Discount Factor	Present Worth on ABD
Elect. (1) 85-89	3.5	7.5	5	16.1	$(1.0528)^{3.5}$	19.3	4.278	82.6	$(\frac{1}{1.1})^{3.5} = 0.7164$	59.2
(2) 90-09	8.5	17.5	20	16.1	$(1.0528)^{3.5}(1.04)^{5}$	20.7	9.768	201.1	$(\frac{1}{1.1})^{8.5} = 0.4448$	89.9
M&R	3.5	27.5	25	91.0	$(1.0)^{3.5}$	91.0	9.985	908.6	0.7164	650.9

	Initial Costs		Energy/Fuel Costs		M&R Costs		Other Costs		Total
Net Present Worth:	4255	+	149	+	651	+	0	=	5055

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Sheet ____ of ____

Project No. & Title PN 003(FY84) Wastewater T.F.
Installation & Location Fort Oaks, Alabama
Design Feature Process
Date of Study 1 Jan 82

LIFE CYCLE COST ANALYSIS
SUMMARY

For use of this form, see TM 5-802-1; the proponent agency is USACE.

ALTERNATIVES ANALYZED

No.	Description/Title	Present Worth ☒ $ x 10³ ☐ $ x 10⁶ Initial	Energy	M&R	Other	Total
A	Conventional Trickling Filter	2104	86	692	0	2882
B	Innovative: RBC	2837	156	858	0	3851
C	Innovative: Cont. Loop Reactor	2616	162	1323	0	4101
D	Conventional Land Spray Irrig.	4255	149	651	0	5055

ECONOMIC RANKING

Rank	Alternative No. & Title	Economic Advantages of Top-Ranked Alternative: LCC (PW) Difference (Dollars & Percent)	Other (Initial, Energy, Etc.)	Basis for No. 1 Ranking
1	A Conventional Trickling Filter	$536,000, 16%	Lowest initial cost, Least energy consumption	Lowest LCC
2	B Innovative: RBC			
3	C Innovative: Cont. Loop Reactor			
4	D Conventional Land Spray Irrig.			

KEY ASSUMPTIONS	NARRATIVE SUMMARY (Comments/Lessons Learned/Observations/Recommendations/Etc.)
	Alternative D would be a more competitive alternative if $2.5 million in land acquisition were not involved.
	115% of PW of alternative A = $3314 x 10³

Key Participants - Name	Discipline	Organization	Telephone No.
Bill Johnson, PE	Sanitary/Environ.	Environmental Eng.	(205) 525-1000
Ken Williams, PE	Mechanical	Environmental Eng.	(205) 525-1000
Steve Smith, PE	Electrical	Environmental Eng.	(205) 525-1000
Bob Washington, PE	Civil	Environmental Eng.	(205) 525-1000

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APPENDIX B

TABLES OF FACTORS FOR PRESENT WORTH CALCULATIONS: CONVENTIONAL APPROACH

B-1. Tables B-1 and B-2 provide annual cash-flow-series equivalence factors–i.e., factors which make it possible to compute the one-time-cost equivalent of an annual cash-flow series directly-for a series of constant or uniformly escalating, annually recurring cash flows. These factors are presented as ratios of (1) the magnitude of the equivalent one-time cost for the series (i.e., the PW of the series), at the time of the first cash flow in the series, and (2) the magnitude of the first cash flow in the series. Table B-1 is based on a 7 percent discount rate, and table B-2 is based on a 10 percent discount rate. The tables cover differential escalation rates from -5 percent through +10 percent, including O percent, in 1 percent increments. They provide equivalence factors for series of 1, 2, . ..30. 40, 45, and 50 annual cash flows (payments, income, savings, etc.).

Table B-1 Annual cash-flow-series equivalence factors – annual discount rate = 7.00%

NO. IN SERIES	-5%	-4%	-3%	-2%	-1%	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%	NO. IN SERIES
							ANNUAL ESCALATION RATE										
1 *	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	* 1
2 *	1.888	1.897	1.907	1.916	1.925	1.935	1.944	1.953	1.963	1.972	1.981	1.991	2.000	2.009	2.019	2.028	* 2
3 *	2.676	2.702	2.728	2.755	2.781	2.808	2.835	2.862	2.889	2.917	2.944	2.972	3.000	3.028	3.056	3.085	* 3
4 *	3.376	3.424	3.473	3.523	3.573	3.624	3.676	3.728	3.781	3.835	3.889	3.944	4.000	4.056	4.114	4.171	* 4
5 *	3.997	4.072	4.149	4.227	4.306	4.387	4.470	4.554	4.640	4.727	4.817	4.907	5.000	5.094	5.190	5.288	* 5
6 *	4.549	4.654	4.761	4.871	4.984	5.100	5.219	5.341	5.466	5.595	5.727	5.862	6.000	6.142	6.287	6.437	* 6
7 *	5.039	5.175	5.316	5.461	5.612	5.767	5.927	6.092	6.262	6.438	6.619	6.807	7.000	7.199	7.405	7.617	* 7
8 *	5.474	5.643	5.819	6.002	6.192	6.389	6.594	6.807	7.028	7.257	7.496	7.743	8.000	8.267	8.543	8.831	* 8
9 *	5.860	6.063	6.275	6.497	6.729	6.971	7.224	7.489	7.765	8.054	8.356	8.671	9.000	9.344	9.703	10.078	* 9
10 *	6.203	6.440	6.689	6.951	7.226	7.515	7.819	8.139	8.475	8.828	9.199	9.590	10.000	10.431	10.884	11.361	* 10
11 *	6.507	6.778	7.064	7.366	7.686	8.024	8.381	8.759	9.158	9.581	10.028	10.500	11.000	11.529	12.088	12.679	* 11
12 *	6.777	7.081	7.404	7.747	8.111	8.499	8.911	9.349	9.816	10.312	10.840	11.402	12.000	12.636	13.314	14.035	* 12
13 *	7.017	7.353	7.712	8.095	8.505	8.943	9.411	9.912	10.449	11.023	11.637	12.295	13.000	13.755	14.563	15.428	* 13
14 *	7.230	7.597	7.991	8.414	8.869	9.358	9.883	10.449	11.058	11.714	12.420	13.181	14.000	14.883	15.835	16.861	* 14
15 *	7.419	7.816	8.244	8.706	9.206	9.745	10.329	10.961	11.645	12.385	13.188	14.057	15.000	16.022	17.131	18.334	* 15
16 *	7.587	8.013	8.474	8.974	9.517	10.108	10.750	11.449	12.210	13.038	13.941	14.926	16.000	17.172	18.451	19.848	* 16
17 *	7.736	8.189	8.682	9.219	9.806	10.447	11.147	11.914	12.753	13.673	14.681	15.786	17.000	18.332	19.796	21.404	* 17
18 *	7.869	8.347	8.870	9.444	10.073	10.763	11.522	12.357	13.276	14.289	15.406	16.639	18.000	19.504	21.166	23.004	* 18
19 *	7.986	8.489	9.041	9.649	10.320	11.059	11.876	12.780	13.780	14.889	16.118	17.483	19.000	20.686	22.562	24.649	* 19
20 *	8.091	8.616	9.196	9.838	10.548	11.336	12.210	13.182	14.265	15.471	16.817	18.320	20.000	21.879	23.983	26.340	* 20
21 *	8.183	8.730	9.337	10.010	10.759	11.594	12.525	13.566	14.732	16.037	17.503	19.149	21.000	23.084	25.432	28.079	* 21
22 *	8.266	8.833	9.464	10.168	10.955	11.836	12.823	13.933	15.181	16.588	18.176	19.970	22.000	24.300	26.907	29.866	* 22
23 *	8.339	8.925	9.580	10.313	11.136	12.061	13.104	14.281	15.613	17.123	18.836	20.783	23.000	25.527	28.410	31.703	* 23
24 *	8.403	9.007	9.684	10.446	11.303	12.272	13.369	14.614	16.030	17.643	19.484	21.589	24.000	26.765	29.941	33.592	* 24
25 *	8.461	9.081	9.779	10.567	11.458	12.469	13.620	14.931	16.430	18.148	20.120	22.387	25.000	28.015	31.501	35.534	* 25
26 *	8.512	9.148	9.865	10.678	11.602	12.654	13.856	15.233	16.816	18.639	20.744	23.178	26.000	29.277	33.089	37.530	* 26
27 *	8.557	9.207	9.943	10.780	11.734	12.826	14.079	15.522	17.188	19.117	21.356	23.961	27.000	30.551	34.708	39.583	* 27
28 *	8.598	9.261	10.014	10.873	11.857	12.987	14.289	15.796	17.545	19.581	21.957	24.737	28.000	31.836	36.357	41.693	* 28
29 *	8.633	9.309	10.078	10.959	11.970	13.137	14.488	16.058	17.889	20.032	22.546	25.506	29.000	33.134	38.036	43.861	* 29
30 *	8.665	9.352	10.136	11.037	12.075	13.278	14.676	16.308	18.220	20.470	23.125	26.268	30.000	34.444	39.747	46.091	* 30
35 *	8.778	9.509	10.355	11.340	12.494	13.854	15.467	17.391	19.700	22.484	25.859	29.971	35.000	41.178	48.794	58.214	* 35
40 *	8.840	9.600	10.489	11.535	12.777	14.265	16.060	18.244	20.923	24.231	28.348	33.503	40.000	48.233	58.718	72.133	* 40
45 *	8.874	9.653	10.571	11.661	12.970	14.558	16.505	18.916	21.934	25.747	30.612	36.874	45.000	55.623	69.605	88.117	* 45
50 *	8.893	9.684	10.621	11.742	13.100	14.767	16.838	19.445	22.769	27.062	32.673	40.090	50.000	63.366	81.549	106.471	* 50

Equation:

$$\text{Annual Equivalence Factor} = \frac{1 - v^n}{1 - v}, \text{ where } v = \frac{1 + e}{1 + d}$$

e = annual escalation rate
d = discount rate
n = number of years

Cash Flow Diagram:

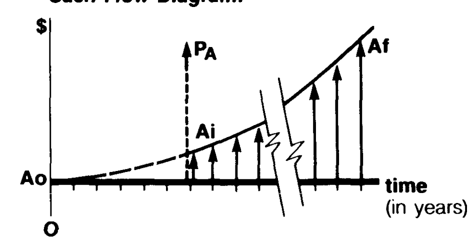


Table B-2 Annual cash-flow-series equivalence factors – annual discount rate = 10.00%

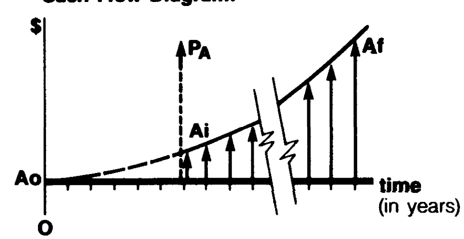
NO. IN SERIES						ANNUAL ESCALATION RATE										NO. IN SERIES
	-5%	-4%	-3%	-2%	-1%	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%	
1 *	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	* 1
2 *	1.864	1.873	1.882	1.891	1.900	1.909	1.918	1.927	1.936	1.945	1.955	1.964	1.973	1.982	1.991	2.000	* 2
3 *	2.610	2.634	2.659	2.685	2.710	2.736	2.761	2.787	2.813	2.839	2.866	2.892	2.919	2.946	2.973	3.000	* 3
4 *	3.254	3.299	3.345	3.392	3.439	3.487	3.535	3.584	3.634	3.684	3.735	3.787	3.839	3.892	3.946	4.000	* 4
5 *	3.810	3.879	3.950	4.022	4.095	4.170	4.246	4.324	4.403	4.483	4.566	4.649	4.735	4.821	4.910	5.000	* 5
6 *	4.290	4.385	4.483	4.583	4.686	4.791	4.899	5.009	5.123	5.239	5.358	5.480	5.605	5.734	5.865	6.000	* 6
7 *	4.705	4.827	4.953	5.083	5.217	5.355	5.498	5.645	5.797	5.953	6.115	6.281	6.453	6.630	6.812	7.000	* 7
8 *	5.064	5.213	5.368	5.529	5.695	5.868	6.048	6.234	6.428	6.628	6.837	7.053	7.277	7.509	7.750	8.000	* 8
9 *	5.373	5.549	5.733	5.925	6.126	6.335	6.553	6.781	7.019	7.267	7.526	7.796	8.078	8.372	8.680	9.000	* 9
10 *	5.641	5.843	6.056	6.279	6.513	6.759	7.017	7.288	7.572	7.871	8.184	8.513	8.858	9.220	9.601	10.000	* 10
11 *	5.871	6.100	6.340	6.594	6.862	7.145	7.443	7.758	8.090	8.441	8.812	9.203	9.616	10.053	10.513	11.000	* 11
12 *	6.071	6.323	6.591	6.875	7.176	7.495	7.834	8.194	8.575	8.981	9.411	9.868	10.354	10.870	11.418	12.000	* 12
13 *	6.243	6.518	6.812	7.125	7.458	7.814	8.193	8.598	9.030	9.491	9.983	10.510	11.072	11.672	12.314	13.000	* 13
14 *	6.392	6.689	7.007	7.347	7.712	8.103	8.523	8.972	9.455	9.973	10.530	11.127	11.770	12.460	13.202	14.000	* 14
15 *	6.520	6.838	7.179	7.546	7.941	8.367	8.825	9.320	9.853	10.429	11.051	11.723	12.449	13.233	14.082	15.000	* 15
16 *	6.631	6.967	7.330	7.723	8.147	8.606	9.103	9.642	10.226	10.860	11.549	12.296	13.109	13.993	14.954	16.000	* 16
17 *	6.727	7.081	7.464	7.880	8.332	8.824	9.358	9.941	10.576	11.268	12.024	12.849	13.752	14.738	15.818	17.000	* 17
18 *	6.809	7.179	7.582	8.021	8.499	9.022	9.593	10.218	10.903	11.653	12.477	13.382	14.377	15.470	16.674	18.000	* 18
19 *	6.881	7.266	7.686	8.146	8.649	9.201	9.808	10.475	11.209	12.018	12.910	13.895	14.985	16.189	17.523	19.000	* 19
20 *	6.943	7.341	7.778	8.257	8.784	9.365	10.005	10.713	11.496	12.362	13.323	14.390	15.576	16.895	18.363	20.000	* 20
21 *	6.996	7.407	7.858	8.356	8.906	9.514	10.187	10.934	11.764	12.688	13.718	14.867	16.151	17.588	19.196	21.000	* 21
22 *	7.042	7.464	7.930	8.445	9.015	9.649	10.353	11.139	12.015	12.996	14.094	15.326	16.711	18.268	20.022	22.000	* 22
23 *	7.082	7.514	7.993	8.523	9.114	9.772	10.506	11.329	12.251	13.287	14.454	15.769	17.255	18.936	20.840	23.000	* 23
24 *	7.116	7.558	8.048	8.594	9.202	9.883	10.647	11.505	12.471	13.562	14.797	16.196	17.784	19.591	21.650	24.000	* 24
25 *	7.146	7.596	8.097	8.656	9.282	9.985	10.776	11.668	12.678	13.822	15.124	16.607	18.299	20.235	22.454	25.000	* 25
26 *	7.171	7.629	8.140	8.712	9.354	10.077	10.894	11.819	12.871	14.069	15.437	17.003	18.800	20.867	23.250	26.000	* 26
27 *	7.193	7.658	8.178	8.761	9.419	10.161	11.003	11.960	13.052	14.301	15.735	17.384	19.287	21.488	24.038	27.000	* 27
28 *	7.212	7.683	8.211	8.806	9.477	10.237	11.102	12.090	13.221	14.521	16.020	17.752	19.761	22.097	24.820	28.000	* 28
29 *	7.229	7.706	8.241	8.845	9.529	10.307	11.194	12.211	13.380	14.729	16.291	18.107	20.222	22.695	25.594	29.000	* 29
30 *	7.243	7.725	8.267	8.880	9.576	10.370	11.278	12.323	13.528	14.926	16.551	18.448	20.671	23.283	26.361	30.000	* 30
35 *	7.290	7.790	8.358	9.006	9.750	10.609	11.606	12.771	14.141	15.759	17.682	19.979	22.736	26.063	30.095	35.000	* 35
40 *	7.313	7.823	8.406	9.076	9.852	10.757	11.820	13.079	14.582	16.389	18.578	21.250	24.535	28.600	33.661	40.000	* 40
45 *	7.323	7.840	8.432	9.116	9.913	10.849	11.960	13.290	14.899	16.864	19.288	22.307	26.102	30.914	37.069	45.000	* 45
50 *	7.329	7.848	8.446	9.138	9.948	10.906	12.051	13.435	15.127	17.223	19.851	23.185	27.466	33.026	40.324	50.000	* 50

Equation:

Annual Equivalence Factor $= \frac{1 - v^n}{1 - v}$, **where** $v = \frac{1 + e}{1 + d}$

e = annual escalation rate
d = discount rate
n = number of years

Cash Flow Diagram:



B-2. Table B-3 provides escalation factors for differential escalation rates from -5 percent through +10 percent, in 1 percent increments, for escalation periods of 1/4, 1/2, 3/4, 1, 2, ... 30, 35, 40, 45, and 50 years.

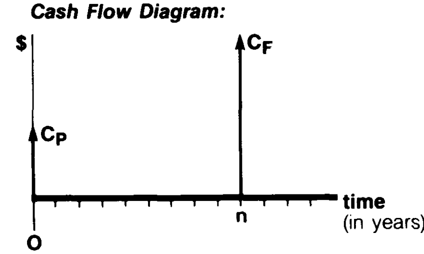
Table B-3 Escalation factors

YEARS TO ESCALATE		-5%	-4%	-3%	-2%	-1%	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%		YEARS TO ESCALATE
1	*	0.950	0.960	0.970	0.980	0.990	1.000	1.010	1.020	1.030	1.040	1.050	1.060	1.070	1.080	1.090	1.100	*	1
2	*	0.903	0.922	0.941	0.960	0.980	1.000	1.020	1.040	1.061	1.082	1.102	1.124	1.145	1.166	1.188	1.210	*	2
3	*	0.857	0.885	0.913	0.941	0.970	1.000	1.030	1.061	1.093	1.125	1.158	1.191	1.225	1.260	1.295	1.331	*	3
4	*	0.815	0.849	0.885	0.922	0.961	1.000	1.041	1.082	1.126	1.170	1.216	1.262	1.311	1.360	1.412	1.464	*	4
5	*	0.774	0.815	0.859	0.904	0.951	1.000	1.051	1.104	1.159	1.217	1.276	1.338	1.403	1.469	1.539	1.611	*	5
6	*	0.735	0.783	0.833	0.886	0.941	1.000	1.062	1.126	1.194	1.265	1.340	1.419	1.501	1.587	1.677	1.772	*	6
7	*	0.698	0.751	0.808	0.868	0.932	1.000	1.072	1.149	1.230	1.316	1.407	1.504	1.606	1.714	1.828	1.949	*	7
8	*	0.663	0.721	0.784	0.851	0.923	1.000	1.083	1.172	1.267	1.369	1.477	1.594	1.718	1.851	1.993	2.144	*	8
9	*	0.630	0.693	0.760	0.834	0.914	1.000	1.094	1.195	1.305	1.423	1.551	1.689	1.838	1.999	2.172	2.358	*	9
10	*	0.599	0.665	0.737	0.817	0.904	1.000	1.105	1.219	1.344	1.480	1.629	1.791	1.967	2.159	2.367	2.594	*	10
11	*	0.569	0.638	0.715	0.801	0.895	1.000	1.116	1.243	1.384	1.539	1.710	1.898	2.105	2.332	2.580	2.853	*	11
12	*	0.540	0.613	0.694	0.785	0.886	1.000	1.127	1.268	1.426	1.601	1.796	2.012	2.252	2.518	2.813	3.138	*	12
13	*	0.513	0.588	0.673	0.769	0.878	1.000	1.138	1.294	1.469	1.665	1.886	2.133	2.410	2.720	3.066	3.452	*	13
14	*	0.488	0.565	0.653	0.754	0.869	1.000	1.149	1.319	1.513	1.732	1.980	2.261	2.579	2.937	3.342	3.797	*	14
15	*	0.463	0.542	0.633	0.739	0.860	1.000	1.161	1.346	1.558	1.801	2.079	2.397	2.759	3.172	3.642	4.177	*	15
16	*	0.440	0.520	0.614	0.724	0.851	1.000	1.173	1.373	1.605	1.873	2.183	2.540	2.952	3.426	3.970	4.595	*	16
17	*	0.418	0.500	0.596	0.709	0.843	1.000	1.184	1.400	1.653	1.948	2.292	2.693	3.159	3.700	4.328	5.054	*	17
18	*	0.397	0.480	0.578	0.695	0.835	1.000	1.196	1.428	1.702	2.026	2.407	2.854	3.380	3.996	4.717	5.560	*	18
19	*	0.377	0.460	0.561	0.681	0.826	1.000	1.208	1.457	1.754	2.107	2.527	3.026	3.617	4.316	5.142	6.116	*	19
20	*	0.358	0.442	0.544	0.668	0.818	1.000	1.220	1.486	1.806	2.191	2.653	3.207	3.870	4.661	5.604	6.727	*	20
21	*	0.341	0.424	0.527	0.654	0.810	1.000	1.232	1.516	1.860	2.279	2.786	3.400	4.141	5.034	6.109	7.400	*	21
22	*	0.324	0.407	0.512	0.641	0.802	1.000	1.245	1.546	1.916	2.370	2.925	3.604	4.430	5.437	6.659	8.140	*	22
23	*	0.307	0.391	0.496	0.628	0.794	1.000	1.257	1.577	1.974	2.465	3.072	3.820	4.741	5.871	7.258	8.954	*	23
24	*	0.292	0.375	0.481	0.616	0.786	1.000	1.270	1.608	2.033	2.563	3.225	4.049	5.072	6.341	7.911	9.850	*	24
25	*	0.277	0.360	0.467	0.603	0.778	1.000	1.282	1.641	2.094	2.666	3.386	4.292	5.427	6.848	8.623	10.835	*	25
26	*	0.264	0.346	0.453	0.591	0.770	1.000	1.295	1.673	2.157	2.772	3.556	4.549	5.807	7.396	9.399	11.918	*	26
27	*	0.250	0.332	0.439	0.580	0.762	1.000	1.308	1.707	2.221	2.883	3.733	4.822	6.214	7.988	10.245	13.110	*	27
28	*	0.238	0.319	0.426	0.568	0.755	1.000	1.321	1.741	2.288	2.999	3.920	5.112	6.649	8.627	11.167	14.421	*	28
29	*	0.226	0.306	0.413	0.557	0.747	1.000	1.335	1.776	2.357	3.119	4.116	5.418	7.114	9.317	12.172	15.863	*	29
30	*	0.215	0.294	0.401	0.545	0.740	1.000	1.348	1.811	2.427	3.243	4.322	5.743	7.612	0.063	13.268	17.449	*	30
35	*	0.166	0.240	0.344	0.493	0.703	1.000	1.417	2.000	2.814	3.946	5.516	7.686	10.677	14.785	20.414	28.102	*	35
40	*	0.129	0.195	0.296	0.446	0.669	1.000	1.489	2.208	3.262	4.801	7.040	0.286	14.974	21.725	31.409	45.259	*	40
45	*	0.099	0.159	0.254	0.403	0.636	1.000	1.565	2.438	3.782	5.841	8.985	3.765	21.002	31.920	48.327	72.890	*	45
50	*	0.077	0.130	0.218	0.364	0.605	1.000	1.645	2.692	4.384	7.107	11.467	18.420	29.457	46.902	74.358	117.391	*	50
.25	*	0.987	0.990	0.992	0.995	0.997	1.000	1.002	1.005	1.007	1.010	1.012	1.015	1.017	1.019	1.022	1.024	*	.25
.50	*	0.975	0.980	0.985	0.990	0.995	1.000	1.005	1.010	1.015	1.020	1.025	1.030	1.034	1.039	1.044	1.049	*	.50
.75	*	0.962	0.970	0.977	0.985	0.992	1.000	1.007	1.015	1.022	1.030	1.037	1.045	1.052	1.059	1.067	1.074	*	.75

Equation:

Escalation Factor = $(' + e)^n$, where e = annual escalation rate
n = number of years of escalation

Cash Flow Diagram:



B-3. Table B-4 provides discount factors for discount rates of 7 and 10 percent for discounting periods of 1/4, 1/2, . . . 3/4, 1, 2, 30, 40, 45, and 50 years.

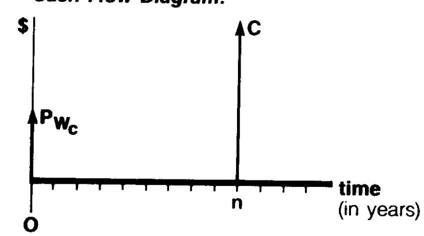
Table B-4 Discount factors

YEARS		DISCOUNT 7%	RATE 10%		YEARS
1	*	0.9346	0.9091	*	1
2	*	0.8734	0.8264	*	2
3	*	0.8163	0.7513	*	3
4	*	0.7629	0.6830	*	4
5	*	0.7130	0.6209	*	5
6	*	0.6663	0.5645	*	6
7	*	0.6227	0.5132	*	7
8	*	0.5820	0.4665	*	8
9	*	0.5439	0.4241	*	9
10	*	0.5083	0.3855	*	10
11	*	0.4751	0.3505	*	11
12	*	0.4440	0.3186	*	12
13	*	0.4150	0.2897	*	13
14	*	0.3878	0.2633	*	14
15	*	0.3624	0.2394	*	15
16	*	0.3387	0.2176	*	16
17	*	0.3166	0.1978	*	17
18	*	0.2959	0.1799	*	18
19	*	0.2765	0.1635	*	19
20	*	0.2584	0.1486	*	20
21	*	0.2415	0.1351	*	21
22	*	0.2257	0.1228	*	22
23	*	0.2109	0.1117	*	23
24	*	0.1971	0.1015	*	24
25	*	0.1842	0.0923	*	25
26	*	0.1722	0.0839	*	26
27	*	0.1609	0.0763	*	27
28	*	0.1504	0.0693	*	28
29	*	0.1406	0.0630	*	29
30	*	0.1314	0.0573	*	30
35	*	0.0937	0.0356	*	35
40	*	0.0668	0.0221	*	40
45	*	0.0476	0.0137	*	45
50	*	0.0339	0.0085	*	50
.25	*	0.9832	0.9765	*	.25
.50	*	0.9667	0.9535	*	.50
.75	*	0.9505	0.9310	*	.75

Equation:

Discount Factor $= \frac{1}{(1 + d)^n}$, **where** d = **discount rate**
n = **number of years escalation**

Cash Flow Diagram:



APPENDIX C

DEPARTMENT OF ENERGY (DOE) REGIONS

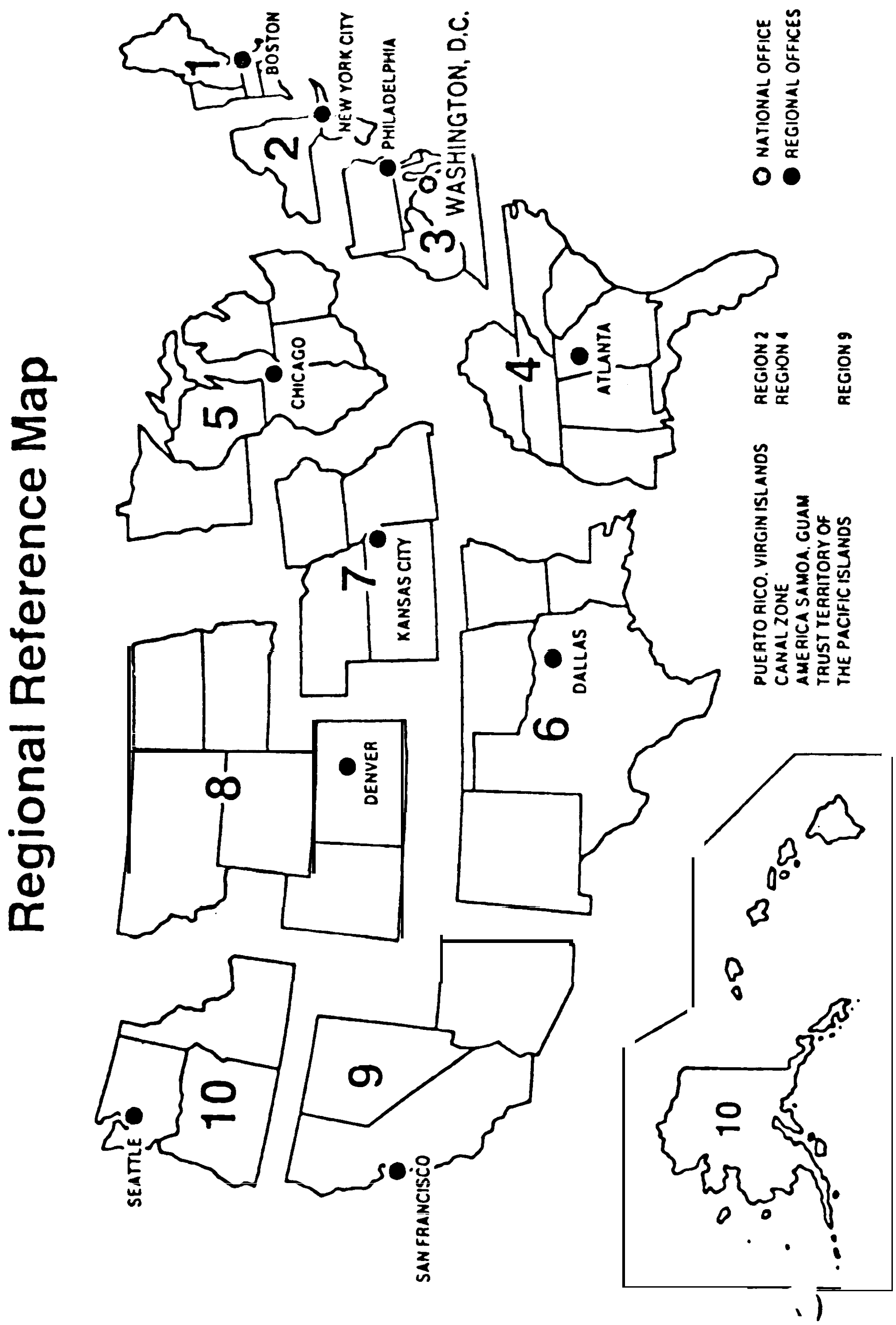


Figure C-1. Regional Reference Map

REGION NUMBER BY STATE

STATE	DOE REGION NO.	STATE	DOE REGION NO.
ALABAMA	4	MISSOURI	7
ALASKA	10	MONTANA	8
ARIZONA	9	NEBRASKA	7
ARKANSAS	6	NEVADA	9
CALIFORNIA	9	NEW HAMPSHIRE	1
COLORADO	8	NEW HERSEY	2
CONNECTICUT	8	NEW MEXICO	6
DELAWARE	1	NEW YORK	2
DISTRICT OF COLUMBIA	3	NORTH CAROLINA	4
FLORIDA	3	NORTH DAKOTA	8
GEORGIA	4	OHIO	5
HAWAII	9	OKLAHOMA	6
IDAHO	10	OREGON	10
ILLINOIS	5	PENNSYLVANIA	3
INDIANA	5	RHODE ISLAND	1
IOWA	7	SOUTH CAROLINA	4
KANSAS	7	SOUTH DAKOTA	8
KENTUCKY	4	TENNESSEE	4
LOUISIANA	6	TEXAS	6
MAINE	1	UTAH	8
MARYLAND	3	VERMONT	1
MASSACHUSETTS	1	VIRGINIA	3
MICHIGAN	5	WASHINGTON	10
MINNESOTA	5	WEST VIRGINIA	3
MISSISSIPPI	4	WISCONSIN	5
		WYOMING	8

Figure C-1. Regional Reference Map—Continued

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General, United States Army
Chief of Staff

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Brigadier General, United States Army
The Adjutant General

DISTRIBUTION:

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Project No. & Title ____________________

Installation & Location ____________________

Design Feature ____________________

Baseline System ____________________

Investment ____________________

LIFE CYCLE COST ANALYSIS

SAVINGS-TO-INVESTMENT RATIO (SIR) & DISCOUNTED PAYBACK CALCULATION

For use of this form, see TM 5-802-1; the proponent agency is USACE.

SIR Calculation				Discounted Payback Calculation				
Element of Calculation	System	Type of Cost/Benefit		Trial Values of Post-BOD Analysis Period, n(years)				
				n =	n =	n =	n =	n =
PW of Operating & Maintenance Costs ☐ $ x 10³ ☐ $ x 10⁶	Base-line	Energy/Fuel						
		Other O&M						
		Total						
	Invest-ment	Energy/Fuel						
		Other O&M						
		Total						
	Δ	Net Savings						
PW of Capital Costs ☐ $ x 10³ ☐ $ x 10⁶	Base-line	Initial (MCP)						
		Replacements						
		Terminal						
		Other						
		Total Net						
	Invest-ment	Initial (MCP)						
		Replacements						
		Terminal						
		Other						
		Total Net						
	Δ	Extra Investment						
SIR	Δ	Net Savings / Extra Investment						

Next Trial n Value (Years)	A = This SIR — 1.0						
	B = This SIR — Last SIR*						
	C = Ratio of A to B						
	D = Last n* — This n						
	E = Product of C & D						
	F = Next n = This n + E						

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*In calculating First Trial n Value for Discounted Payback Calculation, Use Last SIR = Last n = 0.

Sheet ______ of ______

LIFE CYCLE COST ANALYSIS

SUMMARY

Project No. & Title ______________________

Installation & Location ______________________

Design Feature ______________________

For use of this form, see TM 5-802-1; the proponent agency is USACE.

Date of Study ______________________

ALTERNATIVES ANALYZED						
No.	Description/Title	Present Worth [ ] $ x 10^3 [ ] $ x 10^6				
		Initial	Energy	M&R	Other	Total

ECONOMIC RANKING				
Rank	Alternative No. & Title	Economic Advantages of Top-Ranked Alternative		Basis for No. 1 Ranking
		LCC (PW) Difference (Dollars & Percent)	Other (Initial, Energy, Etc.)	

KEY ASSUMPTIONS

NARRATIVE SUMMARY (Comments/Lessons Learned/Observations/Recommendations/Etc.)

Key Participants - Name	Discipline	Organization	Telephone No.

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Sheet ________ of ________

Project No. & Title ______________________

Installation & Location ______________________

Design Feature ______________________

LIFE CYCLE COST ANALYSIS

BASIC INPUT DATA SUMMARY

For use of this form, see TM 5-802-1; the proponent agency is USACE.

Criteria Reference		
Date of Study (DOS)		
Analysis Base Date (ABD)		
Analysis End Date (AED)		
Midpoint of Construction		
Beneficial Occupancy Date (BOD)	Actual Projected	
	Assumed for Analysis	
DOE Region		
Annual Discount Rate		

Type of Cost	Differential Escalation Rate per Year (%)		
	Timeframe:		

Principal Assumptions

Cash Flow Diagram

Cost Element	Cost on ABD ☐ $ x 10^3 ☐ $ x 10^6	Time Cost Incurred**		Source(s) of Data
		Actual Projected Dates	Dates for Analysis (If Different)*	

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*When 10 CFR436A Criteria Apply

**For Recurring Annual Costs, show date of first and last costs only.

Sheet ________ of ________

Project No. & Title

Installation & Location

Design Feature

Alt. No. ______ Title

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: CONVENTIONAL APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

Criteria Reference	
Analysis Base Date (ABD)	
Analysis End Date (AED)	
Midpoint of Construction	
BOD for Analysis	
Annual Discount Rate	

Type of Cost	Differential Escalation Rate per Year (%)	
	Timeframe:	

One-Time Costs ☐ $ x 10³ ☐ $ x 10⁶

Years From ABD	Cost on ABD	Escalation Factor	Escal.Cost (Time Incurred)	Discount Factor	Present Worth on ABD

Annual Costs ☐ $ x 10³ ☐ $ x 10⁶

Years from ABD: First Incurred	Years from ABD: Last Incurred	Total No. of Payments	Annual Cost on ABD	Escalation Factor	Escal.Cost (Time First Incurred): 1st Ann. Cost in Series	Escal.Cost (Time First Incurred): Annual Series Eq Factor	Escal.Cost (Time First Incurred): Equiv. Single Cost	Discount Factor	Present Worth on ABD

Net Present Worth:	Initial Costs	Energy/Fuel Costs	M&R Costs	Other Costs	Total

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Sheet ______ of ______

Project No. & Title ____________________

Installation & Location ____________________

Design Feature ____________________

Alt. No. ________ Title ____________________

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: ONE-STEP APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

One-Time Costs [ ] $ x 10^3 [ ] $ x 10^6	Years from ABD	Cost On ABD	One Step Adj.Factor Table 1	Present Worth on ABD

Criteria Reference	
Analysis Base Date (ABD)	
Analysis End Date (AED)	
Midpoint of Construction	
BOD for Analysis	
Annual Discount Rate	

Type of Cost	Differential Escalation Rate per Year (%)		
	Timeframe:		

Annual Costs [ ] $ x 10^3 [ ] $ x 10^6	Total No. of Payments	Annual Cost on ABD	Total Nominal Cost on ABD	One Step Adjustment Factor* Table Factor x DOS Correction	Present Worth on ABD

	Initial Costs		Energy/Fuel Costs		M&R Costs		Other Costs		Total
Net Present Worth:	________	+	________	+	________	+	________	=	________

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*Use One-Step Table 2 for M&R costs (e = 0).
Use One-Step Table 3 for energy/fuel costs (e = prescribed e value).

Sheet ________ of ________

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